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GEASTER LIMBATUS: A NEW VARIETY

ELIZABETH EATON MORSE

(WITH 8 FIGURES)

A colony of large earthstars was found growing from abundant matted mycelium under a juniper hedge in Berkeley, California, after the heavy autumn rains in 1933. The first collection consisted of eighteen specimens, in each of which there was a violet-pinkish coloration in the fleshy layer next to the spore sac. This coloration suggested *Geaster rufescens* but there were several characters in this material which did not conform to the descriptions of that species. We submitted specimens to Doctor W. C. Coker, who returned the determination *G. limbatus,* also he very kindly forwarded a specimen of what he believes is typical *G. rufescens* which grew in Chapel Hill, North Carolina. Basing judgment on this specimen our geasters plainly were not *G. rufescens.* In fact the spores resembled, rather, those of *G. limbatus,* but no record of a pinkish coloration in the fleshy layer of that species could be found. Since this western material is not *G. rufescens,* macroscopically or microscopically, and since it resembles *G. limbatus* microscopically, it seems advisable to describe it as a variety of the latter.

Geaster limbatus Fries var. **pacificus** var. nov.

Fungus immaturus globoso-depressus; fungus maturus laciniis patentibus usque ad 10 cm. latus; exoperidio sordibus vestito; strato carnoso crasso, fragili, puniceo-tincto. Columella immaturitate percurrens.

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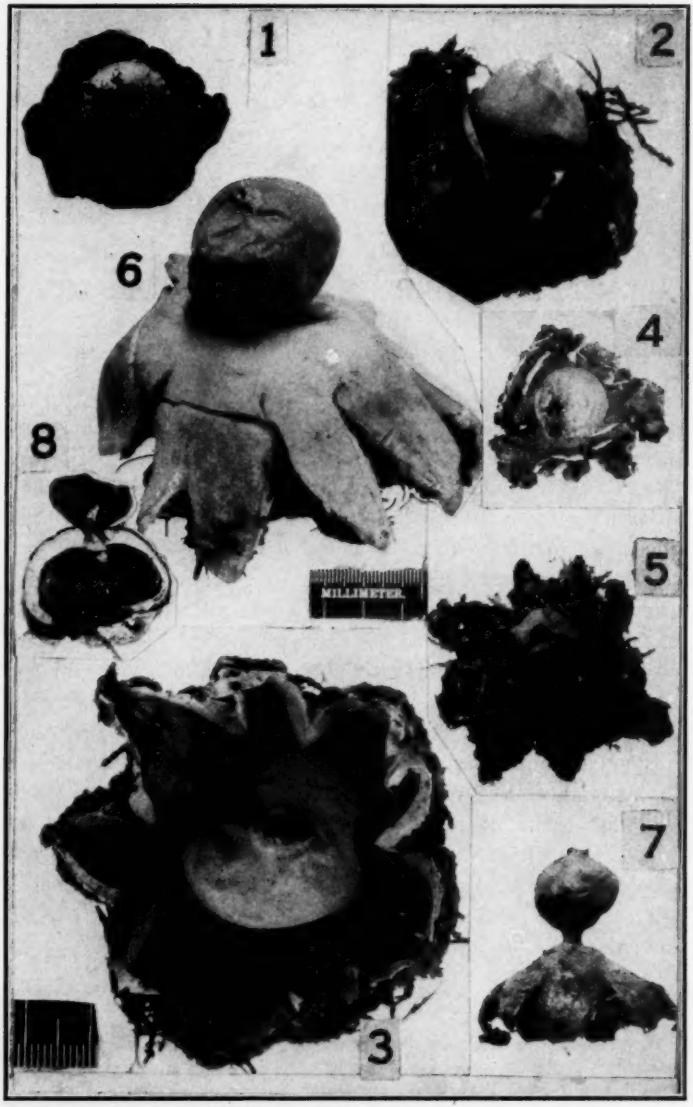

FIGS. 1–8. *Geaster limbatus* var. *pacificus*.

Button globose flattened, not at all pointed, entirely submerged; outer mycelial layer flaky and pliable, holding firmly a thick mass of soil and trash, may separate from the middle fleshy layer. Expanded, the fleshy layer is smooth, brittle when fresh, not pitted or spongy, up to 4 mm. thick, with a pinkish coloration in the exposed surface, this coloring fading or quite disappearing in wet weather; fleshy layer when dried very thin, about one-half mm. thick, reddish brown; inner peridium (spore sac) with definite stout stalk, up to 5 mm. thick and 3–4 mm. long, not showing in the fresh plant until the segments roll back; spore sac 1.5–3 cm. thick, subspherical, pale gray when fresh, later may become dark brown depending on the weather and the number of spores held on the surface; definite apophysis usually in evidence; mouth when fresh rather definite, more silky shining than the case and surrounded by a shallow groove, later becomes elevated, fimbriate and indefinite. Center of outer peridium always arched on under side, but rays very variable in position—much cupped around the spore sac, or nearly plane, or well reflexed, according to the amount of moisture present while maturing. Columella percurrent in early stage, definite, may extend when mature one-third way into the glebal chamber. Spores purplish brown, spherical, strongly warted when mature, 4–5.5 μ, capillitium up to 7 μ thick.

The variety differs from what is regarded as typical *G. limbatus* in its larger size, the much more trashy outer layer which may separate from the fleshy layer, the pinkish coloration of the fleshy layer, and also the more pronounced stalk and less elongated tips of the rays. It differs from *G. rufescens* in its longer stalk, much thinner and not spongy fleshy layer when dry, the more firmly adhering outer mycelial layer, and the rougher spores which are less deeply colored *en masse*. The correspondence of spores with *G. limbatus* rather than with *G. rufescens,* the pronounced columella, and the pinkish coloration in fleshy layer are three outstanding characters of the variety.

Aside from the type collection, University Calif. Herb. No. *506573,* specimens have been collected since 1933 in the same limited area, also under geraniums which border the adjacent sidewalk. A single specimen was collected in soil under a small tree on University of California Campus near Life Sciences Building (Morse, March 8, 1936); also, under *Chamaecyparis Lawsoniana,* Hotel Claremont garden, Berkeley (Morse, Spring, 1938, 1939).

The largest specimen we have (10 cm.) grew under an *Adenostoma fasiculatum* on steep west-facing canyon slope, south of Nortonville, Contra Costa Co. (Lee, Jan. 12, 1936). A collection was made in duff under *Aesculus* and *Umbellularia*, Hotel Rafael, San Rafael, Marin Co. (L. Bonar, Nov. 28, 1937); Regional Park, Wild Cat Canyon (M. Spurrier, 1938); another collection, buried in leaf mold in oak woods, Rocky Nook Park, Santa Barbara (P. M. Rea, March 10, 1939). Recent collections: in black soil on thin *Umbellularia* duff, gregarious, Wild Cat Canyon, Contra Costa Co. (Robert Y. Wing, Jan. 4, 1939; Feb. 11, 1940); on *Acacia* duff, south of Boalt Hall, U. C. Campus, Berkeley (V. Ranzoni, Nov. 1, 1940).

I am indebted in this study to F. J. Seaver who kindly sent material from the New York Botanical Garden; to W. C. Coker and Alma Holland, University of North Carolina; to John Dearness, Canada; to Carleton Rea, England; to Lee Bonar and Vera M. Miller, University of California.

CALIFORNIA MYCOLOGICAL SOCIETY,
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BERKELEY, Dec. 1, 1940

EXPLANATION OF FIGURES

FIGS. 1–8. Photographs by W. C. Matthews. *Geaster limbatus* var. *pacificus:* 1, early stage, button cracked on one side, shows a smooth, grayish spore sac; tips of blunt rays not extended; 2, spore sac emerging from exoperidium which is loaded with soil and juniper trash; peristome elevated, fibrillose, surrounded by pallid silky zone; 3, expanding rays split half way, cupped about the spore sac, showing marked difference in coloration of exposed surface and flesh beneath; tips of rays at this stage often inrolled; 4, fleshy layer cracked shows white flesh beneath. Mouth silky fibrillose; 5, button submerged but close to surface of juniper duff, expanded after heavy rains; nine segments may be distinguished, spore sac elevated above the trash; mouth determinate (young) showing definite ridge; 6, fresh young specimen, rays turned back, fleshy layer thick, brittle; pale pinkish coloration in exposed surface; spore sac not yet elevated, pedicel not yet in view; 7, fully mature, spore sac elevated, mouth now indeterminate, distinct apophysis, pedicel laterally compressed; fleshy layer shrunken to one-half mm.; exoperidium still loaded with trash; 8, vertical median section, conical columella extends one third the way into glebal chamber; extensive mycelial layer still intact, not at all fornicate; in typical *G. limbatus* the columella is "obsolete" (Cleland) or small and "knob-like" (Coker).

Note: Figs. 1, 2, 3, 6, cm. scale; 4, 5, 7, 8, mm. scale.

UREDINALES OF NEW GUINEA [1]—III

GEORGE B. CUMMINS [2]

(WITH 7 FIGURES)

The 54 species of Uredinales reported in this paper were collected by Mrs. Mary Strong Clemens in Morobe District, New Guinea. Of the 54 species one is transferred as a new combination and 12 are described as new species. The type specimens are deposited in the Arthur Herbarium, Purdue University Agricultural Experiment Station.

PUCCINIASTRUM BOEHMERIAE (Dietel) Sydow.

On *Boehmeria* sp., Sattelberg, Oct. 9, 1935 (*339*); above Kajabit, Jan. 4, 1939 (*10921*); Ogao to Samanzing, June 26, 1939 (*10280*); Samanzing to Milulunga, July 5, 1939 (*10434*).

COLEOSPORIUM MERRILLII P. Henn.

On Orchidaceae, Wareo, Jan. 3, 1936 (*1486*).

Phakopsora Oplismeni (Arth. & Cumm.) comb. nov. (*Uredo Oplismeni* Arth. & Cumm. Phil. Jour. Sci. **59**: 442. 1936) (FIG. 2).

Telia hypophyllous, subepidermal, oval or elongate, 0.1–0.15 × 0.3–1.0 mm., golden-brown, darkening with age, compact, waxy in appearance, not remaining covered by the epidermis, 3–8 spores thick, the upper layers collapsing after germination, not firmly united, irregularly arranged; teliospores ellipsoid, oblong or cuboid, 9–16 × 14–23 μ; wall hyaline or yellowish, smooth, 0.5–1 μ thick; germinating at once.

On *Oplismenus compositus* (L.) Beauv., Kajabit Mission, Aug. 12, 1939 (*10568*).

[1] Contribution from the Department of Botany, Purdue University Agricultural Experiment Station, Lafayette, Indiana.

The second article of this series was published in Mycologia **33**: 64–68. 1941.

[2] I am indebted to Drs. E. D. Merrill and J. R. Swallen for giving opinions concerning the identity of some of the hosts.

PHAKOPSORA PACHYRHIZI Sydow.

On *Mucuna* ? sp., Kajabit Mission, Sept. 26, 1939 (*10707*).

CEROTELIUM DESMIUM (Berk. & Br.) Arth.

On *Gossypium* sp., Kajabit Mission, Nov. 23, 1939 (*10827*).

FIG. 1, free-hand, slightly stained section of a telium of *Cerotelium morobeanum* on *Derris;* 2, free-hand, slightly stained section of the marginal portion of a telium of *Phakopsora Oplismeni* on *Oplismenus;* 3, teliospores of *Puccinia Digitariae* on *Digitaria* (× 800).

Cerotelium morobeanum sp. nov. (FIG. 1).

Uredia hypophylla, subepidermalia, laxe aggregata, rotundata, minuta, 75–130 μ diam.; periphysibus inferne conjunctis, hyalinis, inconspicuis; urediosporae ellipsoideae vel obovoideae, 16–20 × 20–26 μ; membrana flavidula vel pallide brunnea, 1.5 μ cr., minuteque echinulata; poris germ. obscuris. Telia hypophylla, laxe aggregata, rotundata, 75–100 μ diam., compacta, aureo-brunnea; teliosporae oblongae, 6–8 × 10–15 μ; membrana hyalina, 0.5–1 μ cr.

On *Derris* sp., Kajabit Mission, Aug. 16, 1939 (*10581*, type), Sept. 8, 1939 (*10674*).

CROSSOPSORA ANTIDESMAE-DIOICAE (Racib.) Arth. & Cumm.

On *Antidesma ghaesembella* Gaertn., Kajabit Mission, Oct. 21, 1939 (*10794*).

GOPLANA DIOSCOREAE (Berk. & Br.) Cumm.

On *Dioscorea* sp., Salamaua, May 27, 1936 (*3176*).

ACHROTELIUM ICHNOCARPI Sydow.

On *Ichnocarpus* sp., Finschhafen, Sept. 3, 1935 (*50*); Kajabit Mission, Sept. 8, 1939 (*10673 bis*).

Skierka Clemensiae sp. nov. (FIG. 4).

Uredia amphigena, aggregata in maculis 0.5–2.0 mm. diam., subepidermalia, poro aperta, 0.1–0.25 mm. diam.; urediosporae ellipsoideae, obovoideae vel plus minusve fusoideae, 10–15(–17) × (20–)23–30(–33) μ; membrana hyalina, 1.5 μ cr., moderate echinulata; poris germ. obscuris. Telia adhuc ignota.

On *Canarium* sp., Kajabit Mission, Aug. 31, 1939 (*10629*).

Skierka Clemensiae differs from *S. philippinensis* Mains in having smaller urediospores with walls of uniform thickness. The echinulation is more uniformly distributed with no marked tendency toward longitudinal arrangement.

UROMYCES LEPTODERMUS Sydow.

On *Ischaemum* sp., Wareo, Jan. 11, 1936 (*1603*). On *Setaria geniculata* (Lam.) Beauv., Samanzing, Dec. 6, 1938 (*10417*A); Wantoat, Jan. 10, 1940 (*10948*). On *Setaria palmifolia* (Willd.) Stapf., Wantoat, Jan. 7, 1940 (*10939*).

UROMYCES PEGLERIAE Pole Evans.

On *Digitaria violascens* Link, Ogao, June 20, 1939 (*10359*).

UROMYCES APLUDAE Sydow & Butler.

On *Apluda mutica* L., Kajabit Mission, Aug. 31, 1939 (*10631*); Wantoat, Jan. 10, 1940 (*10949*).

UROMYCES PYRIFORMIS Cooke.

On *Acorus calamus,* L., Kajabit Mission, Aug. 22, 1939 (*10598*).

UROMYCES COMMELINAE Cooke.

On *Commelina* cf. *benghalensis,* Finschhafen, Sept. 9, 1935 (*87*). On undet. Commelinaceae, Sattelberg, Sept. 26, 1935 (*226*).

PUCCINIA POGONATHERI Petch.

On *Pogonatherum paniceum* (Lam.) Hack., Sattelberg, Oct. 4, 1935 (*318*), Oct. 1935 (*332b*); Wantoat, Jan. 13, 1940 (*10979*).

PUCCINIA RUFIPES Dietel.

On *Imperata cylindrica* (L.) Beauv., Heldsbach, Sept. 9, 1935 (*88*); Kajabit Mission, Sept. 8, 1939 (*10668*); Sept. 18, 1939 (*s. n.*). On *Imperata* sp., Wantoat, Jan. 12, 1940 (*11007a*).

PUCCINIA CITRATA Sydow.

On *Cymbopogon citratus* (DC.) Stapf., Wareo, Feb. 5, 1936 (*1818*); Sattelberg, Feb. 28, 1936 (*1910*); Quembung, Mar. 27–28, 1936 (*s. n.*); Yoangen, June 18, 1936 (*s. n.*); Malalo Mission and Salamaua, May 23–24, 1936 (*3160*).

PUCCINIA SORGHI Schw.

On *Zea Mays* L., Yunzaing, July 20, 1936 (*3666*).

PUCCINIA AIRIAE (Lagerh.) Cruchet & Mayor.

On *Deschampsia Klossii* Ridl., vicinity of Samanzing, Dec. 30, 1938 (*9441; 10326J*).

A few small epiphyllous, subepidermal, aparaphysate telia with clavate teliospores measuring 17–23 × 36–48 μ were found in this material and agree with the description published by Cruchet and Mayor. The paraphysate uredia also correspond.

PUCCINIA POAE-SUDETICAE (Westend.) Jørstad.

On *Anthoxanthum Horsfieldii* (Kunth) Mez, Mt. Sarawaket, Apr. 14, 1939 (*10132*), June 8, 1939 (*10231*). On *Poa longiramea* Hitchc., Mt. Sarawaket, Apr. 12, 1937 (*6147*), Apr. 14, 1939 (*10133*), June 15, 1939 (*10238a*), Feb. 21, 1939 (*9870*);

vicinity of Samanzing, Dec. 10, 1938 (*9439*), Dec. 11, 1939 (*10323B*), Dec. 1939 (*10469H*).

Only uredia are present in these collections.

PUCCINIA PYGMAEA Erikss.

On *Calamagrostis Brassii* Hitchc., Mt. Sarawaket, June 15, 1939 (*10238*).

This rather meager specimen has only uredia but the urediospores and paraphyses indicate *P. pygmaea*.

PUCCINIA RUBIGO-VERA (DC.) Wint.

On *Brachypodium longisetum* Hitchc., Upper Camp A, Mt. Sarawaket, Mar. 11, 1939 (*10016; 10017*), Apr. 6, 1939 (*s. n.*).

A few teliospores of the size and shape of those of *P. rubigo-vera* were seen but mature telia are not present.

PUCCINIA ORIENTALIS (Sydow & Butler) Arth. & Cumm.

On *Panicum* sp., Malalo Mission, Salamaua, May 23, 1936 (*3161A*).

PUCCINIA CYNODONTIS Lacroix.

On *Cynodon dactylon* (L.) Pers., Sambanga, Nov. 2, 1937 (*7483*).

PUCCINIA LEVIS (Sacc. & Bizz.) Magn.

On *Digitaria pruriens* (Fisch.) Buse, Kajabit Mission, Aug. 30, 1939 (*10630*).

PUCCINIA DIGITARIAE Pole Evans (FIG. 3).

On *Digitaria pertenuis* Buse, Wareo, Feb. 4, 1936 (*1835*); Wantoat, Jan. 10, 1940 (*10947C*). On *Digitaria pruriens* (Fisch.) Buse, Kajabit Mission, Aug. 30, 1938 (*10630A*), Kajabit Mission, Markham Valley, Sept. 18, 1939 (*s. n.*). On *Digitaria* sp., Wantoat, Jan. 12, 1940 (*10971*).

P. Digitariae is described as having four equatorial pores but in these collections the pores, while commonly four, vary from four to six. The uredia have paraphyses as described and the telia and teliospores, present only in the Markham Valley collection, are characteristic.

PUCCINIA PAULULA Sydow.

On *Alocasia* ? sp., Kajabit Mission, Oct. 20, 1939 (*10786*).

The sori of this rust are nearly extrastomatal in development but the spores, borne on simple pedicels, are initiated subepidermally. *P. paulula* was described from the Philippines on *Amorphophallus campanulatus*. Through the kindness of Dr. D. H. Linder I was enabled to compare the Philippine and New Guinea specimens. No substantial difference exists.

PUCCINIA EXHAUSTA Dietel.

On *Clematis* sp., Kajabit Mission, Sept. 8, 1939 (*10658*), Oct. 20, 1939 (*10779B*).

Puccinia eluta sp. nov. (FIG. 5).

Pycnia epiphylla, subepidermalia, paraphysata, 100–175 μ diam. Aecia hypophylla vel petiolicola, in maculis leniter incrassatulis rotundatis vel elongatis usque ad 10 mm. longis aggregata, cupulata, 0.2–0.3 mm. diam., flavida; cellulis peridii ellipsoideis vel oblongis, 25–35 × 35–60 μ, pariete interiore verrucoso 3 μ cr., exteriore 2 μ cr. levi; aeciosporae ellipsoideae vel oblongo-ellipsoideae, 19–28 × 32–53 μ; membrana pallide flavida, 1.5–2 μ cr., ad apicem 2–10 μ cr., moderate et denseque verrucosa. Uredia nulla. Telia hypophylla, subepidermalia, rotundata, 0.1–0.2 mm. diam., in greges 1–2 mm. diam. disposita, flavida; teliosporae ellipsoideae, utrinque rotundatae, medio constrictae, 24–29 × 38–48 μ; membrana 1.5 μ cr., pallide flavida, levi; pedicello hyalino, sporam breviore.

On *Deeringa* sp., Sattelberg, Jan. 19, 1935 (*1265*); Wantoat, Jan. 7, 1940 (*10930*, type).

In gross appearance the aecia of *P. eluta* are similar to those of *P. calosperma* Sydow but the aeciospores are larger. The smooth pale teliospores are entirely different from the teliospores of *P. calosperma*.

PUCCINIA ENGLERIANA P. Henn.

On *Tabernaemontana* sp., Kajabit Mission, Sept. 15, 1939 (*10694*).

Puccinia morobensis sp. nov. (FIG. 6).

Pycnia amphigena, subepidermalia, globoidea, 125–175 μ diam. Aecia amphigena, subepidermalia, rotundata, 0.3–0.4 mm. diam., aperidiata, in maculis aureis usque 8 mm. diam. aggregata; aeciosporae ellipsoideae, oblongo-ellipsoideae vel obovoideae, 23–32 × 32–46 μ; membrana hyalina vel pallide flavida 3–6 μ cr., moderate aculeata, ad apicem et basim 5–12 μ et plus

minusve levi. Uredia hypophylla, sparsa vel laxe aggregata, cinnamomea, 0.1–0.3 mm. diam.; urediosporae late ellipsoideae vel obovoideae, 23–28 × 29–35 μ; membrana pallide cinnamomea 1.5 μ cr., moderate echinulata; poris germ. 2, aequatorialibus. Telia uredia conformibus; teliosporae ellipsoideae vel oblongo-ellipsoideae, utrinque rotundatae, medio constrictae, 24–29 × 33–45 μ; membrana pallide castanea vel aurea, 1.5 μ cr., minuteque echinulata vel apparenter levi; poro superiore apicali, inferiore medium loculum sito;

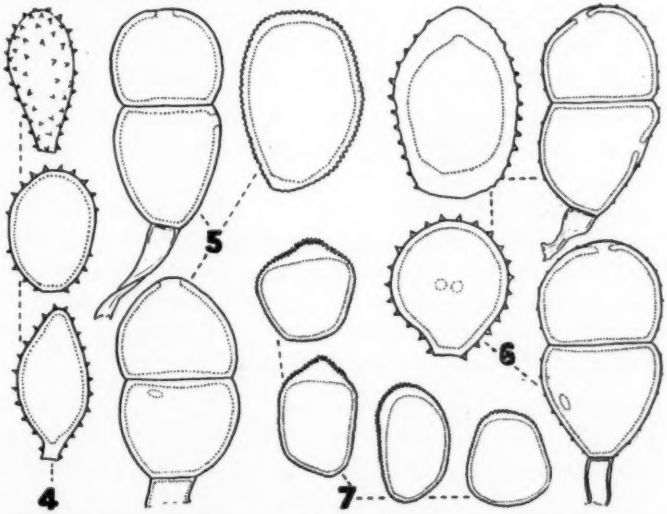

FIG. 4, three urediospores of *Skierka Clemensiae* on *Canarium;* 5, two teliospores and one aeciospore of *Puccinia eluta* on *Deeringa;* 6, one aeciospore, one urediospore and two teliospores of *Puccinia morobensis* on *Tabernaemontana;* 7, four aeciospores of *Aecidium papuanum* on *Blumea* (× 650).

pedicello hyalino, fragili, brevi.

On *Tabernaemontana* sp., Sattelberg to Quembung, Nov. 26, 1935 (*1017a*).

This rust, because of the aculeate aeciospores, differs from both *P. Engleriana* P. Henn. and *P. Tabernaemontanae* Berk. & Br. The teliospores are similar to those described for *P. Tabernaemontanae* but the urediospores are significantly smaller.

PUCCINIA THWAITESII Berk.

On *Justicia Gendarussa* Burm. f., Kajabit Mission, Aug. 9, 1939 (*10563*), Nov. 12–14, 1939 (*10820*); Wantoat, Jan. 8, 1940 (*s. n.*).

PUCCINIA FALLAX Arth.

On *Psychotria* sp., Bandong, mts. above Boana, July 4, 1938 (*8435*); Kajabit Mission, Aug. 31, 1939 (*10632*).

I can detect no differences between the urediospores and teliospores of these collections and American material of the species. Previous telial collections have been on *Palicouria*, with only uredia known on *Psychotria*. *P. Palicouriae* Mains is a similar rust but has more strongly echinulate urediospores.

ENDOPHYLLUM EMASCULATUM Arth. & Cumm.

On *Breynia* sp., Sattelberg, Nov. 2, 1935 (*s. n.*); Quembung Mission, Mar. 23, 1936 (*2150*); Samanzing, July 5, 1939 (*s. n.*); Wantoat, Jan. 15, 1940 (*10990bis*).

This is a rust of uncertain relationship. The compact nature of the sori indicates a strong lateral adherence of the spores. Free-hand sectioning may separate the sorus from the host but the spore mass remains intact even in thin sections. The species is undoubtedly microcyclic, although germination has not been observed, and perhaps is near the relatively obscure genus *Dietelia*.

UREDO ARTHRAXONIS-CILIARIS P. Henn.

On *Arthraxon hispidus* (Thunb.) Merr., Heldsbach, Oct. 1935 (*s. n.*); *Sattelberg*, Feb. 28, 1936 (*s. n.*); Ogao, June 20, 1938 (*s. n.*).

UREDO POLLINIAE-IMBERBIS S. Ito.

On *Eulalia ciliata* (Trin.) Kuntze, Boana, May 2, 1938 (*8150*).

This collection is meager and can be referred only tentatively to *U. Polliniae-imberbis*. The species may belong in *Angiopsora* or *Phakopsora*.

Uredia hypophyllous, golden, with peripheral incurved paraphyses united below, 9–15 × 35–50 μ, the wall 1.5–4 μ thick on the outer side and at the apex, thin on the inner side; urediospores obovoid or broadly ellipsoid, 18–20 × 23–28 μ, the wall hyaline or yellowish; finely and closely echinulate, the pores obscure.

Uredo ogaoensis sp. nov.

Urediis hypophyllis, rotundatis vel ovatis, 0.1–0.3 mm. longis, brunneis, maculis purpureo-brunneis occupantibus; paraphysibus copiosis, capitatis, 13–19 × 35–50 μ; membrana flavida, 1.5–2 μ cr., ad apicem 3–8 μ; urediosporae ellipsoideae vel ovoideae, 15–22 × 19–24(–26) μ; membrana obscure cinnamomea, 1–1.5 μ cr., minuteque echinulata; poris germ. 4, aequatorialibus.

On *Microstegium nudum* (Trin.) Camus, Ogao to Samanzing, June 26, 1939 (*10279*, type); Samanzing, June 28, 1939 (*10380*).

The sori of *U. ogaoensis* are similar to the uredia of *Puccinia aestivalis* Dietel, judging from the description, but the urediospores of *U. ogaoensis* are smaller and darker colored.

Uredo themedicola sp. nov.

Urediis hypophyllis, oblongis, 0.2–0.6 mm. longis, sparsis vel seriatim dispositis, pallide cinnamomeis; urediosporae globoideae, 19–23 × 21–26 μ; membrana aureo- vel cinnamomeo-brunnea, 1.5–2 μ cr., minuteque echinulata; poris germ. 6–8, sparsis.

On *Themeda triandra* Forsk., Markham Valley, Kajabit Mission, Aug. 31, 1939 (*10633B*).

This rust differs from *Uredo Themedae* Dietel, and *Puccinia burmanica* Sydow & Butler, in having echinulate urediospores.

UREDO GENICULATA Cumm.

On *Sorghum nitidum* (Vahl) Pers. (*Andropogon serratus* Thunb.), Kajabit Mission, Sept. 8, 1939 (*10665*).

UREDO PASPALINA Sydow.

On *Paspalum cartilagineum* Presl, Wareo, Dec. 31, 1935 (*1413*); Sattelberg, Mar. 10, 1936 (*2004*); Lae vicinity, July 15, 1939 (*s. n.*). On *Paspalum longifolium* Roxb., Kajabit Mission, Sept. 27, 1939 (*10706*), Oct. 18, 1939 (*10787*).

Uredo Palmifoliae sp. nov.

Urediis amphigenis vel praecique hypophyllis, minutis, in maculis brunneis elongatis sparsis dispositis; paraphysibus periphericis copiosis, incurvatis, cylindraceis; membrana hyalina vel pallide flavida, pariete interiore 1.5–2 μ cr., exteriore 3–6 μ cr.; urediosporae obovoideae, ellipsoideae vel late ellipsoideae, 17–20 × 21–27 (–29) μ; membrana flavida 1–1.5 μ cr., minuteque echinulata; poris germ. obscuris.

On *Setaria palmifolia* (Willd.) Stapf., Sattelberg, Mar. 13, 1936 (*2958*, type), May 7, 1936 (*3069*).

Mrs. Clemens describes this rust as "golden" but in the dried condition it is brownish. The uredia have the characteristics of those of *Angiopsora* or *Phakopsora*.

Uredo Musae sp. nov.

Urediis hypophyllis, subepidermalibus, rotundatis, minutis, 65–120 μ diam., poro apertis, brunneis, laxe aggregatis vel plus minusve striiformibus;

urediosporae fere sessiles, late ellipsoideae, ellipsoideae vel obovoideae, (14–)17–21 × 24–30(–34) μ; membrana hyalina vel pallide brunneola, 1.5 μ cr., moderate echinulata; poris germ. obscuris.

On *Musa*, sp., Boana, May 6, 1936 (*8182*); Kajabit Mission, Sept. 8, 1939 (*10664*), Oct. 20, 1939 (*10779*, type).

The urediospores of this species have thinner and more strongly echinulate walls than described for those of *Uromyces Musae* P. Henn.

UREDO DIOSCOREA-SATIVAE Sydow.

On *Dioscorea* sp., Kajabit Mission, Dec. 8, 1939 (*10863L*); Wantoat, Jan. 7, 1940 (*10933*).

Uredo hiulca sp. nov.

Uredia hypophylla, subepidermalia, irregulariter rotundata vel elongata, 0.2–0.8 mm. longa, bullata, flavida, in maculis flavidis 1–3 mm. diam. aggregata vel sparsa; urediosporae ellipsoideae, obovoideae vel oblongae, 16–23 × 25–36 μ; membrana 1.5–2 μ cr., pallide flavida vel hyalina, minuteque echinulata; poris germ. obscuris sed 6–8 plus minusve aequatorialibus.

On *Dioscorea* sp., Finschhafen, Sept. 3, 1935 (*51*); Kajabit Mission, Nov. 27, 1939 (*10930*, type), Jan. 4, 1940 (*10917A*).

The spores of this species are of about the same size as those of *Uredo Dioscoreae-sativae* Sydow, but the sori are larger and have no peridium. Other species described on *Dioscorea* have smaller spores with the exception of *Uredo Dioscoreae-filiformis* Racib., which has larger, thicker-walled and more strongly echinulate spores.

UREDO ERYTHRINAE P. Henn.

On *Erythrina* sp., Lae, July 21, 1939 (*10461*); Kajabit Mission, Sept. 16, 1939 (*s. n.*).

Uredo wantoatensis sp. nov.

Uredia hypophylla, subepidermalia, rotundata, 0.3–0.8 mm. diam., pulverulenta, cinnamomea, in maculis brunneis usque ad 3 mm. diam. aggregata; urediosporae late ellipsoideae, 15–18 × 18–23 μ; membrana aureo- vel cinnamomeo-brunnea, 1.5 μ cr., moderate echinulata; poris germ. 2, aequatorialibus.

On *Impatiens* sp., Wantoat, Jan. 9, 1940 (*10944A*).

Uredo wantoatensis perhaps will be found to have teliospores similar to those of *Puccinia argentata* (Schultz) Wint. and *P. Komarovi* Tranz. but should still be readily distinguishable since

the urediospores of *P. argentata* have several scattered pores while those of *P. Komarovi* have but a single pore.

UREDO OPHIORRHIZAE Petch.

On *Ophiorrhiza* sp., Ogeramnang to Bulung R., Jan. 4, 1937 (*4858*); Samanzing to Milulunga, July 5, 1939 (*s. n.*); Kajabit Mission, Oct. 20, 1939 (*10778F*).

AECIDIUM BREYNIAE Sydow.

On *Breynia* sp., Salamaua, Aug. 26, 1935 (*17*); Heldsbach, Sept. 15, 1935 (*122*); Kajabit Mission, Aug. 12, 1939 (*10571*).

Aecidium Breyniae is characteristic because of its hypophyllous, subcuticular, conical, minute pycnia, which measure only 20–35 μ in diameter.

Aecidium morobeanum sp. nov.

Pycnia epiphylla, subepidermalia, paraphysata, 100–130 μ diam. Aecia hypophylla, cupulata, 0.2–0.3 mm. diam., in maculis flavidis vel brunneis 2–12 mm. diam. disposita; cellulis peridii globoideis, ellipsoideis vel cuboideis, 21–30 μ diam., pariete interiore verrucoso 3 μ cr., exteriore minuteque striato 3 μ cr.; aeciosporae globoideae vel ellipsoideae, 22–29 × 28–33(–36) μ; membrana hyalina, 1.5–2 μ cr., moderate verrucosa.

On *Cordia dichotoma* Forst. f., Kajabit Mission, July 25, 1939 (*10493*, type), Sept. 21, 1939 (*s. n.*), Nov. 23, 1939 (*s. n.*), Dec. 1939 (*s. n.*).

The aeciospores of this rust are larger than those of *A. brasiliensis* Dietel, and *A. Lindavianum* Sydow, and lack the apical thickening characteristic of the spores of *A. Cordiae* P. Henn. No other spore form could be found and, since the material varied from fresh to old, the species is probably heteroecious.

AECIDIUM MICRANTHUM Sydow.

On *Psychotria* sp., Samanzing, Dec. 22, 1938 (*9443; 9444*).

AECIDIUM FLAVIDUM Berk. & Br.

On *Pavetta indica* L. var., Sattelberg to Quembung Mission, Nov. 26, 1935 (*1018*), Dec. 9, 1935 (*1174b*); Kajabit Mission, Aug. 18, 1939 (*10589*), Oct. 16, 1939 (*s. n.*).

AECIDIUM VERNONIAE-CINEREAE Petch.

On *Vernonia cinerea* Less., Boana, July 14, 1938 (*8475*); Kajabit Mission, Dec. 8, 1939 (*10860*).

AECIDIUM BLUMEAE P. Henn.

On *Blumea* sp., above Dantap, Jan. 4, 1940 (*10920*).

Aecidium papuanum sp. nov. (FIG. 7).

Pycniis epiphyllis, subepidermalibus, globoideis, 100–175 μ diam. Aeciis hypophyllis, cupulatis, recurvatis, flavidis, 0.2–0.3 mm. diam., per totam folii superficiem plus minusve aequaliter sparsis; cellulis peridii rhomboideis, 17–23 × 27–35 μ, pariete interiore verrucoso 3–5 μ cr., exteriore 3 μ cr. levi; aeciosporae globoideae, oblongae vel ellipsoideae, 15–23 × 19–26 μ; membrana pallide flavidula vel hyalina, 1 μ cr., ad apicem 2–5 μ cr., ubique sed praecique ad apicem moderate verrucosa.

On *Blumea hieracifolia* DC., Kajabit Mission, Dec. 19, 1939 (*10890*).

The mycelium of *A. papuanum* is at least locally systemic and the affected leaves are smaller and narrower than normal. It is the only systemic *Aecidium* known to parasitize *Blumea*.

THE ARTHUR HERBARIUM,
PURDUE UNIVERSITY AGRICULTURAL EXPERIMENT STATION

A NEW SMUT FROM LOUISIANA

L. WAYNE LENZ

(WITH 2 FIGURES)

An interesting smut, apparently belonging to the genus *Tilletia,* has been collected a number of times during the past two years in Louisiana on two species of *Euphorbia.* The first collections were made by Mr. Alvaro Goenaga near Brusly, La., on *Euphorbia Preslii* Guss. Other collections, also made by Mr. Goenaga, included ones made in September, 1939, at Montegut, La., on *Euphorbia heterophylla* L. (*Poinsettia heterophylla* (L.) Small, according to Small's Manual of the Flora of the Southeastern States), and at Baton Rouge on *Euphorbia Preslii* Guss.

The sori of the smut occur in rather conspicuous spindle-shaped swellings (FIG. 1, 2*a*) on the stems and peduncles. As these swellings split, the somewhat powdery black masses of spores are exposed. The spores (FIG. 2*b–e*) germinate rather readily in a 1 to 100,000 benzaldehyde solution, each promycelium bearing 3–5 sporidia at the tip.

A search was made of all available literature but no record could be found of a smut having ever been reported as occurring on *Euphorbia* or any member of the Euphorbiaceae. As the smut collected in Louisiana is apparently new, it is here described as a new species, as follows:

Tilletia Euphorbiae sp. nov.

Sori forming conspicuous, usually spindle-shaped swellings on stems and peduncles, splitting longitudinally at maturity and exposing the black spore mass; spores rather firmly compacted in indefinite masses in the cortex, dark brown, subspherical to broadly oblong, irregular due to pressure, 11–17 × 14–18 μ (average 14 × 16 μ), smooth, single or in small groups, but not forming definite balls. Germination by means of a short non-septate promycelium bearing at the tip 3–5 sporidia. Sporidia remaining attached and fusing or germinating directly by means of a germ tube.

Soris in stirpibus pedunculisque tumores manifestos et plerumque fusiformes efficientibus, maturis in longitudinem findentibus eoque massam sporarum nigram exhibentibus; sporis firmius compactis in massas informes in cortice sitas; atribrunneis, subglobosis vel late oblongis, propter pressionem irregularibus, 11–17 × 14–18 μ (mediis inter maxima minimaque 14–16 μ), glabris, singulis vel glomeratis, veros autem globos non facientibus.

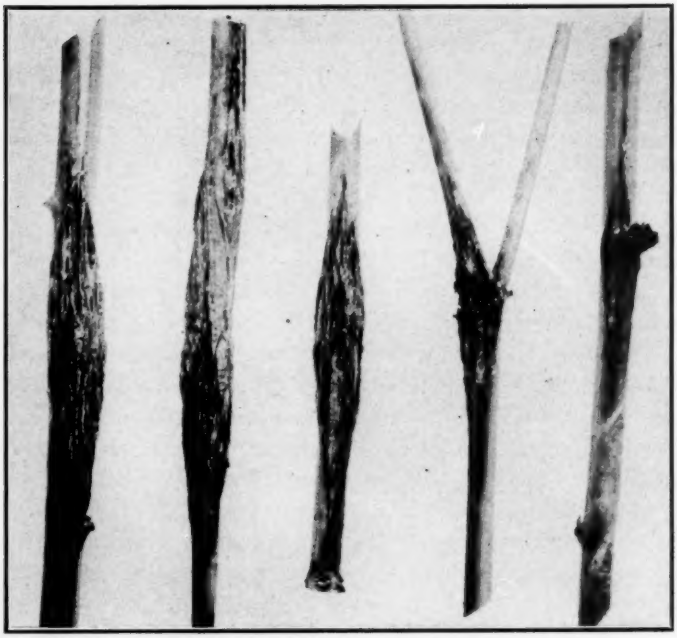

FIG. 1. *Tilletia Euphorbiae.*

Germinatio efficitur per breve promycelium non-septatum quod in cacumine 3–5 sporidia parit.

On Euphorbiaceae: *Euphorbia heterophylla* L. Type collected near Montegut, La., September, 1939, by Alvaro Goenaga, also collected on *E. Preslii* Guss. near Baton Rouge, La., September, 1939.

Herbarium material: The type specimens are deposited in the Mycological Collections of the Bureau of Plant Industry, United

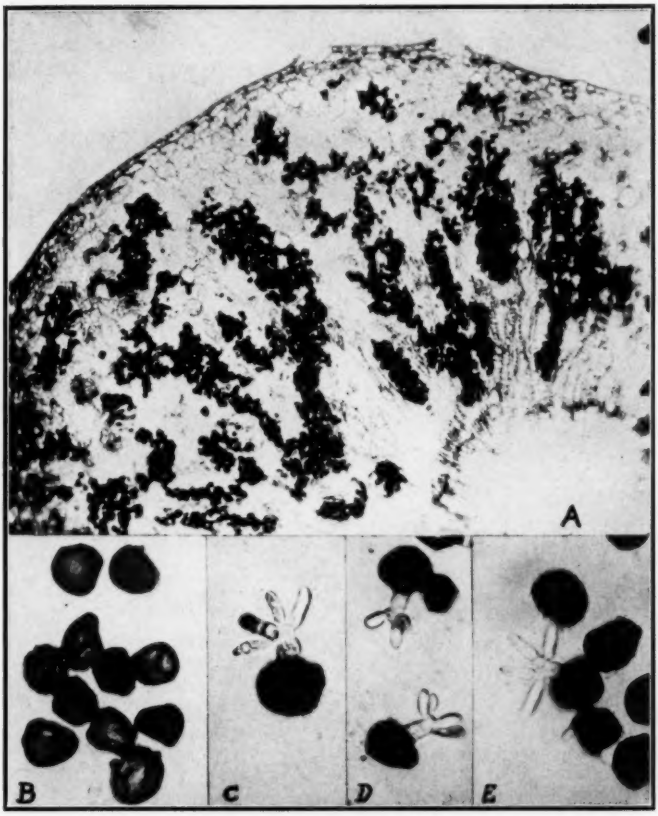

FIG. 2. *Tilletia Euphorbiae.*

States Department of Agriculture at Washington, D. C. Duplicate material is deposited in the herbarium of Louisiana State University, University, La., and the Zundel Herbarium.

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A CONTRIBUTION TO THE LIFE HISTORY AND GEOGRAPHIC DISTRIBUTION OF THE GENUS ALLOMYCES

FRED T. WOLF

(WITH 2 FIGURES)

INTRODUCTION

Almost thirty years ago Butler (**1911**) discovered in India a peculiar aquatic fungus to which he gave the name *Allomyces arbuscula*. This organism is a member of the phycomycetous order Blastocladiales, and possesses two distinct types of sporangia; thin walled zoösporangia, liberating posteriorly uniciliate zoöspores, and thick walled or resistant sporangia, which, after a period of dormancy, release zoöspores similar in all respects to those from the zoösporangia.

It remained for Kniep (**1929**) to describe from Java a second species, *A. javanicus*, which, while having zoösporangia and resistant sporangia as in *A. arbuscula*, also produced paired gametangia liberating male and female gametes structurally similar to the zoöspores except in size. In the next year, Kniep (**1930**) discovered that the gametangia were not produced on the same mycelium as were the two kinds of sporangia; in fact, the life cycle of *A. javanicus* was shown to be characterized by an alternation of generations. The male and female gametangia produced on the sexual mycelium were observed to liberate gametes which fuse to form a motile biciliate zygote, which in turn develops into an asexual mycelium. On the asexual mycelium are borne the thin walled zoösporangia, whose zoöspores form new asexual plants, and thick walled or resistant sporangia, germinating to produce zoöspores which develop into sexual plants. A subsequent reëxamination of *A. arbuscula* by Hatch (**1933, 1935**) disclosed a life cycle identical with that of *A. javanicus*. The distinction between the two species rests, however, on the arrangement

of the gametangia: in *A. javanicus* the male gametangium is terminal or epigynous with respect to the female, whereas in *A. arbuscula* this situation is reversed, the male gametangium being hypogynous.

A third species, *A. moniliformis,* was described by Coker and Braxton (**1926**) from North Carolina, partially on the basis of the fact that the resistant sporangia are characteristically elongate, thus differing markedly from the bluntly rounded resistant sporangia of *A. arbuscula* and *A. javanicus.* The life cycle of *A. moniliformis* has recently been shown (Emerson, **1938**) to be quite different from that of *A. javanicus* and *A. arbuscula.* In this species, zoöspores from the resistant sporangia have been found to be biciliate rather than uniciliate; after a very brief period of motility they encyst, lose their cilia, and each cyst germinates to give rise to a group of four " secondary " zoöspores, each of which is uniciliate and eventually develops into a plant like the immediate parent; *i.e.* bearing the two kinds of sporangia. There is thus no obvious alternation of generations, as in *A. arbuscula* and *A. javanicus.* A fourth species, entirely similar in its life cycle to *A. moniliformis* but with resistant sporangia which are not elongate, has been studied by Emerson (**1938**) and is soon to be described by him under the name *A. cystogenus* (see Emerson and Fox, **1940**). On the basis of these fundamental differences in the life cycles of members of the genus, Emerson (**1939**) has erected the subgenera *Euallomyces* (to include the two long cycled forms) and *Cystogenes* (to include the two cyst-forming species not having alternation of generations).

Still a third life cycle has been shown to exist within the genus; in *A. anomalus* Emerson (**1937**, unpublished) the mycelia bear the characteristic zoösporangia and resistant sporangia resembling those of *Euallomyces,* yet zoöspores from the resistant sporangia develop directly into asexual plants like the parent; *i.e.,* there is no indication of any sexuality whatsoever. The subgenus *Brachyallomyces* (Emerson, **1939**) has been created for this short cycled form.

The present paper has as its aim the presentation of data concerning some 43 new isolates of *Allomyces,* collected by the writer and others during the past several years, and including all of the

described species. Except when otherwise stated, the isolation and identification of the various forms were carried out by the author. This account involves considerable extensions in the known geographic distribution of the genus, and it is to be hoped

FIG. 1. Geographic distribution of the 36 isolates of *Allomyces* obtained from the western hemisphere.

that the information concerning the life cycles of the various isolates will serve to place the taxonomy of the genus, as worked out by Kniep, Hatch, Emerson and others, on a firmer basis.

MATERIALS AND METHODS

Previous workers have shown that the various species of *Allomyces* are to be found under exceedingly diverse environmental conditions both in fresh water and in the soil, and that the resistant sporangia of the fungus are capable of persisting in a dormant but viable condition in the soil for periods of several months or longer. The use of soil samples as a means of obtaining isolates for study has proved to be very satisfactory in the previous experience of the author and others, and hence was used throughout the present work. Inasmuch as it has been impossible for the author to visit personally all of the localities from which collections were made, this report is based almost entirely on collections made by others. The soil samples were collected in a moist condition and allowed to become air dry before shipment. Wrapping of the samples individually in heavy paper precluded the possibility of contamination of one sample with inoculum from another.

Isolation of the fungi was accomplished by placing the soil in a sterile Petri dish with sterile distilled water and using boiled hemp seed as a nutrient substratum. Successive transfers served to free the culture of the bulk of the miscellaneous protozoa, bacteria, and fungi occurring in the soil sample. All observations were based on water cultures of the fungi growing on hemp seed under ordinary laboratory conditions. For purposes of convenience in discussion, each culture was designated by the name of the locality from which it had been collected, together with a number.

One of the chief taxonomic problems of this particular genus is concerned with the possibility of distinguishing between the various species on the basis of asexual characters alone. Although any such evidence must be regarded as presumptive, and confirmed by a careful study of the entire life cycle, nevertheless, the possibility of attempting the correlation of such an obvious character as the size of the resistant sporangia with a particular life cycle or sexual stage is an intriguing one, well deserving of study. Con-

sequently, a series of measurements was made upon the resistant sporangia of each *Allomyces* isolate, and, in order that the results might be comparable, the procedure was carefully standardized. Following a considerable amount of experimentation, it was finally decided to make all measurements on actively growing cultures 5–8 days in age, as experience showed that the vast majority of the resistant sporangia had reached maximal size in this period, whereas older cultures, in which the nutrient supply was practically

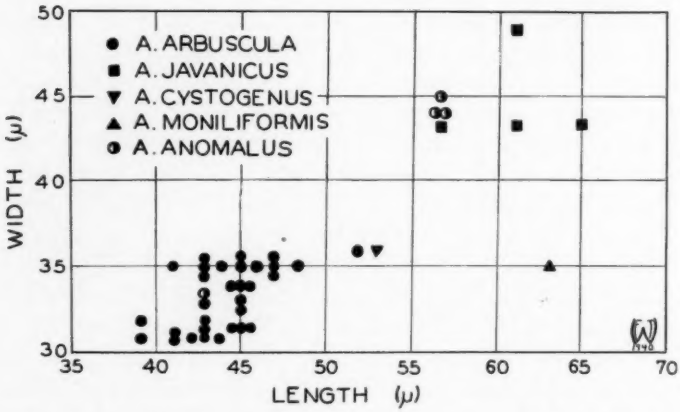

FIG. 2. Graphic representation of the measurements of the resistant sporangia of the various isolates of *Allomyces*.

exhausted, tended to contain a disproportionate quantity of small resistant sporangia. Measurements were made with an ordinary eyepiece micrometer previously calibrated against a standard, and, with the exception of the data concerning the six Mexican isolates reported previously (Wolf, **1939**) and included here for purposes of comparison, the same micrometer, calibration chart, microscope, and observer were used throughout. 100 measurements of the length and 100 measurements of the width of the resistant sporangia of each isolate were made at random. In the case of seven isolates whose large resistant sporangia proved to be more variable in size, the number of measurements was increased to 150.

The results (Table I) are expressed in terms of the mode, rather than the mean, since the frequency distribution curves for resistant

sporangial size are unsymmetrical in character. In expressing the range of variation, 75 per cent of the measurements are included within the arbitrarily established limits, 12.5 per cent of the largest and a similar number of the smallest resistant sporangia being excluded by this procedure.

In conjunction with the measurements carried out on the resistant sporangia of each isolate, the resistant sporangia were germinated in order to work out the complete life cycle. The technique used is a very simple one involving the removal of actively growing asexual mycelia on hemp seed from the water culture, placing them on filter paper, and allowing them to dry out for varying lengths of time (2 weeks to several months). This operation will kill the mycelium and zoöspores from thin walled sporangia, but does not harm the thick walled resistant sporangia. Inasmuch as the resistant sporangia of most isolates will germinate readily when hemp seed and water are again added, this offers an easy and convenient method of obtaining sexual plants for study, and also a means of storing cultures for future use. Inasmuch as the experience of Emerson (**1939**) with *A. anomalus,* and that of Sörgel (**1937**) with certain strains of *A. arbuscula* indicates that resistant sporangia may germinate to produce asexual plants rather than sexual ones, the formation of asexual plants following one such germination experiment does not mean that the same isolate may not again produce sexual plants on another occasion. Consequently, the germination attempts were carried out repeatedly when the sexual stage was not produced, and in many instances, after the consistent production of asexual plants on successive germinations, the sexual stage finally appeared, permitting a species identification to be made.

LIST OF ISOLATES

Inasmuch as so very little is known about the ecological conditions under which *Allomyces* lives in nature, it has been thought wise to include here rather detailed notes concerning the localities from which collections were made, at least in all cases in which this information was available. The approximate location of the sources of the 36 western hemisphere isolates may be seen from the accompanying map (FIG. 1). For purposes of convenience in

TABLE I

COMPARATIVE MEASUREMENTS OF THE RESISTANT SPORANGIA OF THE ISOLATES OF *Allomyces*

	Width (mode in μ)	Length (mode in μ)	75% or more between	
			Width (μ)	Length (μ)
Allomyces arbuscula				
Mexico 26	34	45	28–37	38–48
Mexico 29	34	43	28–38	38–48
Mexico 37	34	45	28–38	40–50
Costa Rica 1	35	47	31–38	40–48
Costa Rica 2	31	44	29–36	39–48
Costa Rica 4	35	45	31–38	40–50
Costa Rica 7	37	52	33–40	46–54
Dominican Rep. 3	31	41	28–34	36–46
Haiti 5	35	46	31–37	43–50
Haiti 11	31	39	28–34	36–44
Haiti 14	35	47	30–38	42–51
Brazil 1	32	45	29–37	41–51
Brazil 2A	32	39	27–35	34–44
Brazil 5	35	43	31–39	39–46
Brazil 2B	33	43	28–36	38–48
Brazil 6	33	45	30–37	39–48
Brazil 9	35	45	31–38	42–49
Brazil 11	31	42	27–34	38–46
Argentina 1	31	43	28–36	38–48
Argentina 2	35	47	31–38	43–50
Argentina 3	32	45	30–36	40–49
Argentina 5	31	43	27–35	38–48
Argentina 6	31	41	26–34	36–44
China 3	34	45	29–37	41–49
China 4	35	44	31–38	39–49
China 5	35	41	30–39	37–46
China 6	35	43	31–37	39–47
China 10	31	43	28–37	38–46
South Africa 1	33	45	30–37	40–49
South Africa 5	32	45	30–38	40–48
Tennessee 1	35	48	33–39	44–52
Allomyces javanicus				
Mexico 17	43	57	34–48	46–61
Texas 1	43	61	37–48	55–70
Utah-Arizona 1	49	61	42–54	54–70
California 1	43	65	38–46	56–70
Allomyces moniliformis				
Mexico 46	35	63	31–38	54–70
Allomyces cystogenus				
Arizona 1	37	53	32–41	46–55
Allomyces anomalus				
Mexico 16	45	57	33–48	45–61
Haiti 7	44	57	38–48	52–67
Haiti 8	44	57	39–49	52–63
Brazil 7	33	43	29–36	38–46

drawing comparisons, the data concerning the measurements of resistant sporangia have been assembled in tabular form (Table I).

ALLOMYCES ARBUSCULA Butler (**1911**) em. Hatch (**1933, 1935**).

This species has proved to be by far the most common and widespread member of the genus. On germination of zoöspores from the resistant sporangia, there are produced, at least occasionally, sexual plants bearing paired gametangia. As described by Hatch (**1933, 1935**), the smaller male gametangium, which is orange pigmented, is hypogynous, while the grayish female gametangium is terminal with respect to the male. Recent work by Emerson and Fox (**1940**) has demonstrated that the coloration of the male gametangium is due to the presence of gamma carotene. There follows an enumeration of the isolates characterized by the possession of such gametangia:

MEXICO 26. Isolated from moist soil collected on August 16, 1937 in the Borda Gardens, Cuernavaca, Morelos, by the author. This isolate was subjected to repeated germination attempts at intervals of several weeks from September, 1937, to June, 1938, resulting in the consistent production of asexual plants. It was therefore described (Wolf, **1939**) as *A. anomala*. Subsequent work by Emerson, however, has demonstrated the existence of a gametophyte of the *A. arbuscula* type.

MEXICO 29. Isolated, as the preceding, from moist soil collected in the Borda Gardens, Cuernavaca, Morelos, on August 16, 1937, by the author.

MEXICO 37. Isolated from mud collected in a roadside ditch near Tepexpan, 6 km. east of Venta de Carpio, on August 18, 1937, by the author.

COSTA RICA 1. Collected by Prof. Rafael L. Rodriguez from the bottom of a shallow pond or puddle covered over with algae and drying up due to lack of rain, near San José, C. R., on November 18, 1939.

COSTA RICA 2. Collected by Prof. Rafael L. Rodriguez from the banks of the Rio Maria Aguila, near San José, C. R., on November 18, 1939.

COSTA RICA 4. Collected by Prof. Rafael L. Rodriguez from a

ditch shaded by trees, near San Dimas, south of San José, C. R., on January 20, 1940.

COSTA RICA 7. Collected by Prof. Rafael L. Rodriguez from Cucubres Creek, south of Desamparados, C. R., on January 20, 1940.

DOMINICAN REPUBLIC 3. Collected by Edwin Anderson from a sink hole in coral rock, surrounded by *Osmunda cinnamomea,* near San Pedro de Macoris, D. R., on October 19, 1939.

HAITI 5. Collected by Arnauld Haspil, from the Cavaillon River, in southern Haiti, on December 1, 1939.

HAITI 11. Collected by Arnauld Haspil, from the Guinte River, in northern Haiti, on December 15, 1939.

HAITI 14. Collected by Arnauld Haspil, from the Momanee River in western Haiti, on December 2, 1939.

BRAZIL 1. Collected on a river bank, near Santa Cruz, Rio Grade do Sul, Brazil, on November 9, 1938, by J. M. Harris.

BRAZIL 2A. Collected in a ditch in a field near Stiendorff's farm, Candelaria, Rio Grande do Sul, Brazil, on November 9, 1938, by J. M. Harris.

BRAZIL 5. From the banks of the Rio Pardo, Candelaria, Rio Grande do Sul, Brazil, on November 9, 1938, by J. M. Harris.

BRAZIL 2B. Collected by W. Hofmann, in the arroio Linha Nova, near Santa Cruz, Rio Grande do Sul, Brazil, on February 13, 1939.

BRAZIL 6. Collected by W. Hofmann, in the arroio Linha Antao, near Santa Cruz, Rio Grande do Sul, Brazil, on February 13, 1939.

BRAZIL 9. Collected by W. Hofmann, in the Rio Castelhano, near Santa Cruz, Rio Grande do Sul, Brazil, on February 13, 1939.

BRAZIL 11. Collected by W. Hofmann, in the arroio Santa Cruz, near Santa Cruz, Rio Grande do Sul, Brazil, on February 13, 1939.

ARGENTINA 1. Collected by E. H. Gartner, from a ditch on the outskirts of Leandro N. Alem, Misiones, Argentina, on February 6, 1939.

ARGENTINA 2. Collected by E. H. Gartner, from a ditch on the outskirts of Leandro N. Alem, Misiones, Argentina, on February 6, 1939.

ARGENTINA 3. Collected by E. H. Gartner, from the river Arreame, Leandro N. Alem, Misiones, Argentina, on February 10, 1939.

ARGENTINA 5. Collected by E. H. Gartner, from the river Martires, Bonpland, Misiones, Argentina, on February 10, 1939.

ARGENTINA 6. Collected by E. H. Gartner, from the river Tacuaruzú, Leandro N. Alem, Misiones, Argentina, on February 10, 1939.

CHINA 3, 4, 5, 6, 10. Collected by Lee Ling from a rice field and the moist bank of a river near Chengtu, China, on February 9, 1939.

SOUTH AFRICA 1. Collected by Miss E. S. Moore from the bank of the Kat River, about a foot above the normal water level but covered during flood periods, near Balfour, Cape Province, South Africa, in March, 1939.

SOUTH AFRICA 5. Collected by Miss E. S. Moore from a roadside pool overgrown with bullrushes, on the Katberg road, near Balfour, Cape Province, South Africa, on January 22, 1940.

TENNESSEE 1. Collected by Miss Dorothy Hutchison in Hibbett's Creek, between Edwin Warner and Percy Warner Parks, near Nashville, Tennessee, on January 3, 1940.

ALLOMYCES JAVANICUS Kniep (**1929**).

This species, like *A. arbuscula,* is characterized by an alternation of generations. Paired gametangia are borne on the sexual mycelium, but their arrangement is just the reverse of that characteristic of *A. arbuscula.* In *A. javanicus,* the brightly pigmented male gametangium is epigynous with respect to the grayish female gametangium (Kniep, **1929, 1930**).

MEXICO 17. Collected by the author from soil in the Rio Pilon, at its intersection with the Pan American Highway, 833 km. north of Mexico City, on August 13, 1937. This isolate was previously described (Wolf, **1939**) as *Allomyces* sp. indet., since the resistant sporangia proved difficult to germinate, and the life cycle was not worked out at the time of the previous report. The author made at that time (op. cit., p. 383) the following statement: "If a sexual stage is ultimately found, it will probably be of the *A. arbuscula* type, as no species with epigynous male gametangia has as yet been

found in the western hemisphere." Emerson, in June, 1939, succeeded in obtaining the sexual stage of this isolate, and has found that its male gametangia are indeed epigynous.

TEXAS 1. Isolated and identified by Dr. F. K. Sparrow, Jr., from soil collected by Prof. G. R. LaRue, in a bog near Grapeland, Texas, in the spring of 1939.

UTAH-ARIZONA 1. Collected and isolated by Dr. J. V. Harvey from dry sand in a wash in the Monument Valley near the boundary line between Utah and Arizona, on August 5, 1937.

CALIFORNIA 1. Collected and isolated by Dr. J. V. Harvey, in sand from a dry wash, Snow Creek, near Palm Springs, California, on February 25, 1940.

As stated above, these collections of *A. javanicus* are the first finds of this species in the western hemisphere. Although *Utah-Arizona 1* represents the earliest new world collection now known to be *A. javanicus,* it would appear that *Mexico 17* was the first isolate to be identified as such.

The sexual plants of the four isolates differ somewhat in the character of their female gametangia. Whereas in *Mexico 17* and *Utah-Arizona 1* the female gametangia are spherical or approximately so, those of *Texas 1* and *California 1* are very strikingly elongate. No difference of comparable degree was apparent among the 31 isolates of *A. arbuscula* studied, in which the gametangia of the various isolates are surprisingly uniform.

ALLOMYCES MONILIFORMIS Coker & Braxton (**1926**) em. Emerson (**1938**).

This species, characterized by elongated resistant sporangia, many of which are pointed at their apices, and by large, widely spaced pits in the wall of the resistant sporangium, has a life cycle involving cyst formation and the escape of secondary zoöspores from the cysts (Emerson, **1938**). It was collected but a single time, as follows:

MEXICO 46. Collected by the author from the Rio Axtla, at its intersection with the Pan American Highway, 399 km. north of Mexico City, on August 20, 1937 (Wolf, **1939**).

ALLOMYCES CYSTOGENUS Emerson (**1940**).

This species, with a life cycle similar to that of *A. moniliformis,* is to be erected to include the four isolates studied by Emerson (**1938**); the species name first appears in the paper by Emerson and Fox (**1940**). The following is the first report of its occurrence in North America:

ARIZONA 1. Collected and isolated by Dr. J. V. Harvey from dry clay in the Gila River, Yuma, Arizona, in March, 1940, and identified by the author.

ALLOMYCES ANOMALUS Emerson (**1937**, unpublished).

This species is characterized by a life cycle involving neither alternation of generations nor cyst-formation; sexual reproduction is apparently lacking completely. Four of the author's isolates apparently belong to this category.

MEXICO 16. Collected at the Rio Pilon at its intersection with the Pan American Highway, 833 km. north of Mexico City, on August 13, 1937, by the author (Wolf, **1939**).

HAITI 7. Collected by Arnauld Haspil from the Coupe à l'Inde River, in central Haiti, on December 15, 1939.

HAITI 8. Collected by Arnauld Haspil from the Estère River, in central Haiti, on December 15, 1939.

BRAZIL 7. Collected by W. Hofmann, from the arroio Quarta Linha Nova, near Santa Cruz, Rio Grande do Sul, Brazil, on February 13, 1939.

Repeated germination of the resistant sporangia of these isolates has failed to give any indication of the possession of a sexual stage.

In addition to the various isolates of *Allomyces,* a parasite of this fungus was also collected, as follows:

ROZELLA ALLOMYCIS Foust (**1937**).

This chytrid, parasitic on *Allomyces arbuscula,* was originally described from North Carolina. Sporangia of the parasite, formed in sori at the tips of young *Allomyces* hyphae, liberate posteriorly uniciliate zoöspores which spread the infection. Large resting spores, 12–20 μ in diameter, with spiny brownish walls, are also produced several days following infection. It is not known

whether or not species of Allomyces other than *A. arbuscula* are subject to attack by this organism. Two isolates of *R. Allomycis* were obtained:

BRAZIL 3. On *A. arbuscula,* from a soil sample collected by W. Hofmann in the river Taquary-Mirim, near Santa Cruz, Rio Grande do Sul, Brazil, on February 13, 1939.

ARGENTINA 4. On *A. arbuscula,* from a soil sample collected by E. H. Gartner from the river Arreame, Leandro N. Alem, Misiones, Argentina, on February 10, 1939.

This parasite has not previously been found to occur in South America. It is easily kept in culture by adding young non-parasitized colonies of *A. arbuscula* to the water culture of the parasitized material, as described by Foust (**1937**), and the resting bodies, when the host material is dried out on filter paper, are capable of remaining viable for several months.

DISCUSSION

The results of the present study would seem to indicate that *Allomyces arbuscula,* and, to a lesser extent, other members of the genus as well, are of fairly common occurrence in moist soils. The finding of this species in the United States, Mexico, the West Indies, Costa Rica, Brazil, and Argentina indicates a rather widespread geographic distribution in the tropical and temperate portions of the western hemisphere, and there seems to be no reason for supposing that future investigations will not disclose a similar lack of endemism in the warmer portions of the eastern hemisphere as well. It is perhaps remarkable that a species having such a wide range as *A. arbuscula* shows so little variation in size of resistant sporangia and characters of the gametangia as is the case.

No correlation whatever seems possible between the observed distribution of this species and the soil type in which it occurs. Isolates were obtained from soils ranging from very rich mucky soils, high in organic matter, to heavy clays, loams, and even sand. Likewise, the factors responsible for bringing about the distribution of such a form in such different geographic and edaphic environments as those in which it occurs, remain almost entirely unknown.

The occurrence of the epigynous species, *A. javanicus*, in the western hemisphere is of especial interest, in view of the fact that it was originally described from Java, and is now known in this hemisphere from at least four localities in the southwestern United States and Mexico, but not elsewhere. Likewise, the finding of *A. cystogenus* for the first time in North America, and the occurrence of *Rozella Allomycis*, reported for the first time from South America, show that our knowledge of the distribution of these forms is far from complete.

The results of the measurements of the resistant sporangia of the various isolates of *Allomyces* indicate that at least a tentative separation between the two long-cycled species, *A. arbuscula* and *A. javanicus*, is possible, using this criterion (FIG. 2). In general, the resistant sporangia of *A. javanicus* are both longer and broader than those of *A. arbuscula*. Whether or not this criterion can be safely used in all cases can be decided only after further study of additional isolates from other localities. Yet the use of measurements, when later confirmed by the germination of the resistant sporangia and observations on the sexual plants, has, in the author's experience, served as an excellent working hypothesis in the identification of the species characterized by an alternation of generations.

Resistant sporangia of the author's isolate of *A. moniliformis* and that described by Coker and Braxton (**1926**) would appear roughly comparable to those of *A. arbuscula* in width, and to those of *A. javanicus* in length. In *A. moniliformis* and *A. cystogenus*, the wide pits in the wall of the resistant sporangia and the presence of the characteristic cysts as described by Emerson (**1938**) offer taxonomic characters of such distinctiveness as to relegate the use of measurements to a position of much less importance in determining species. When more isolates of these cyst-forming species are obtained, however, it is possible that biometric methods could better be used to advantage in helping to delimit the various species of the genus *Allomyces* as Gäumann (**1923**) has done in the genus *Peronospora*.

It is a pleasure to acknowledge the numerous courtesies extended to the author during the progress of this work, a portion of which was carried out during the tenure of a National Research Fellow-

ship in Botany at Harvard University, under the supervision of Professor William H. Weston, Jr., who has provided numerous suggestions and continued encouragement. Dr. Ralph Emerson has been most helpful on many occasions. The writer also wishes to extend his thanks to Dr. F. K. Sparrow, Jr., Dr. J. V. Harvey, Professor Rafael Rodriguez, Edwin Anderson, Arnauld Haspil, J. C. Hart, J. M. Harris, W. Hofmann, E. H. Gartner, Lee Ling, Miss E. S. Moore, Miss Dorothy Hutchison, and Dr. F. A. Wolf for sending cultures or soil samples or helping to secure them, to Mrs. Charles Rick for caring for certain of the cultures during the summer of 1939, and to Miss Ann Vaughn for assistance in making the measurements.

SUMMARY

Allomyces arbuscula has a rather wide geographic distribution, having been found in the United States, Mexico, the West Indies, Costa Rica, Brazil, Argentina, China, and South Africa. Isolates from the various localities appear to be very constant in the characters of their resistant sporangia and gametangia.

Allomyces javanicus is reported for the first time in the western hemisphere, from collections in Mexico, Texas, and the southwestern United States.

Allomyces cystogenus is reported for the first time from North America, from Arizona, and *Rozella Allomycis*, a parasite of *A. arbuscula*, has been found to occur in Argentina and Brazil.

It is suggested that the two long cycled species, *A. arbuscula* and *A. javanicus*, can be very conveniently separated on the basis of resistant sporangial size.

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LITERATURE CITED

Butler, E. J. 1911. On *Allomyces*, a new aquatic fungus. Ann. Bot. **25**: 1023–1034.

Coker, W. C. & H. H. Braxton. 1926. New water molds from the soil. Jour. Elisha Mitchell Soc. **42**: 139–149.

Emerson, Ralph. 1937. Experimental studies of sexuality, heredity, and alternation of generations in *Allomyces*. 117 pp., Ph.D. Thesis, Harvard University (unpublished).

——. 1938. A new life cycle involving cyst-formation in *Allomyces*. Mycologia **30**: 120–132.

——. 1939. Life cycles in the Blastocladiales. Trans. Brit. Myc. Soc. **23**: 123.

—— **& D. L. Fox.** 1940. γ-carotene in the sexual phase of the aquatic fungus *Allomyces*. Proc. Royal Soc. London B **128**: 275–293.

Foust, Frances K. 1937. A new species of *Rozella* parasitic on *Allomyces*. Jour. Elisha Mitchell Soc. **53**: 197–204.

Gäumann, E. 1923. Beiträge zu einer Monographie der Gattung *Peronospora* Corda. Beitr. Krypt. Schweiz **5**: 1–360.

Hatch, W. R. 1933. Sexuality of *Allomyces arbuscula* Butler. Jour. Elisha Mitchell Soc. **49**: 163–170.

——. 1935. Gametogenesis in *Allomyces arbuscula*. Ann. Bot. **49**: 623–649.

Kniep, H. 1929. *Allomyces javanicus*, n. sp., ein anisogamer Phycomycet mit Planogameten. Ber. Deuts. Bot. Ges. **47**: 199–212.

——. 1930. Über die Generationswechsel von *Allomyces*. Zeitschr. Bot. **22**: 433–441.

Sörgel, G. 1937. Untersuchungen über den Generationswechsel von *Allomyces*. Zeitschr. Bot. **31**: 401–446.

Wolf, F. T. 1939. A study of some aquatic Phycomycetes isolated from Mexican soils. Mycologia **31**: 376–387.

NOTES ON OKLAHOMA CERCOSPORAE

W. Winfield Ray

During the course of the last two summers a number of species of *Cercospora* affecting various plants have been collected in Oklahoma. Samples of some of these have been sent to Dr. C. D. Chupp for study, and among them he discovered four new species.

At the request of Dr. Chupp, who generously suggested names for some of the species and technical descriptions for all, the following new species are described:

1. **Cercospora viburnicola** sp. nov.

Maculae angularibus vel irregularibus, levis vel largae, rubro-brunneis vel caesio-brunneis; fungus amphigenus, plerumque in dense fasciculatis; conidiophoris dilute olivaceo-brunneis, in masse mediocriter nigeris, rectis vel nonnihil curvatis vel undulatis, raro semel geniculatis, non-ramosis, attenuatis vel nonnihil irregularibus, parce septatis, ad apices pallescatis subtruncatisque, 4–6 × 25–75 μ; conidiis hyalinis, acicularis vel obclavatis, rectis vel nonnihil curvatis, pluriseptatis, septis inconspicuis, ad bases truncatis, ad apices acutis vel subacutis, 2–4 × 20–80 μ.

Hab. in foliis *Viburnum Opulus*.

Leaf lesions angular to irregular involving small to large portions of leaf, reddish-brown to grayish-brown; fruiting amphigenous and usually in dense fascicles; conidiophores pale olivaceous brown, in mass medium dark, straight to slightly curved or undulate, rarely once geniculate, not branched, tip slightly paler, attenuated or somewhat irregular in width, sparingly septate, medium spore scar at subtruncate tip, 4–6 × 25–75 μ; conidia hyaline, acicular to obclavate, straight or slightly curved, indistinctly multiseptate, truncate at the base with subacute to acute tips, 2–4 × 20–80 μ.

Hab.: On leaves of *Viburnum Opulus* in Stillwater, Oklahoma, August 1939.

Type: In the herbarium of the Department of Plant Pathology, Cornell University, No. *29236*.

2. **Cercospora Coreopsidis** sp. nov.

Maculae orbiculares, 2–5 mm. diametro, marginibus elevatis et dilute brunneis, in centrum caesiae vel alutaceae; plerumque fungus epiphyllus;

stromatis cellis paucis tenus 40 μ diametro, atro-fuligenis; plerumque in dense fasciculatis, raro valde dense; conidiophoris in masse nigeris, singulatim dilute fuligenis, nonnihil ad apices attenuatis et pallescatis, 1–3 septatis, non-ramosis, rectis vel leviter curvatis vel tortuosis, raro semel geniculatis, 4–6 × 15–75 μ; conidiis hyalinis, acicularis vel obclavatis, conidiis brevissimis cylindraceis, rectis vel nonnihil curvatis, septis inconspicuis, ad bases truncatis vel subtruncatis, ad apices subacutis, 2–4 × 15–100 μ.

Hab. in foliis *Corcopsis grandiflora.*

Leaf spots circular, 2–5 mm. in diameter, pale brown raised margin and a gray to tan center; fruiting mostly epiphyllous, stromata a few cells to 40 μ in diameter, dark fuligenous; most fascicles dense, rarely very dense; conidiophores dark in mass, but pale fuligenous singly, somewhat paler and attenuate toward the tip, 1–3 septate, not branched, straight to curved or tortuous, rarely once geniculate, 4–6 × 15–75 μ; conidia hyaline, acicular to obclavate, shortest ones may be cylindric, straight to slightly curved, indistinctly multiseptate, truncate to subtruncate base, tip subacute, 2–4 × 15–100 μ.

Hab.: On leaves of *Coreopsis grandiflora* (Mayfield var.) in cultivated garden, Stillwater, Oklahoma, July 1940.

Type: In the herbarium of the Department of Plant Pathology, Cornell University, No. *29234.*

3. **Cercospora Cercidis** sp. nov.

Maculae orbiculares vel angularibus, 0.5–2 mm. diametro, atro-brunneis, interdum in centrum dilutiore cum corono flavo; fungus hypophyllus; stromatis solum cellis paucis, brunneis; interdum in dense fasciculatis; conidiophoris dilute olivaceo-brunneis, uniformis in coloris et latitudinis, parce septatis, non-ramosis, usitate semel geniculatis, ad apices rotundatis vel subtruncatis, 3–4.5 × 15–40 μ; conidiis subhyalinis vel prope coloratis, obclavatis, ad basis obconico-truncatis, rectis vel nonnihil curvatis, ad apices abruptis, 1–4 septatis, 4–6 × 20–50 μ.

Hab. in foliis *Cercis canadensis.*

Leaf lesions circular to angular, 0.5–2 mm. in diameter, dark brown, sometimes with paler center and yellow halo; fruiting hypophyllous; stromata of only few brown cells; some fascicles dense; conidiophores pale olivaceous brown, fairly uniform in color and width, sparingly septate, not branched, but geniculation may be slightly extended, usually one geniculation or 1 to 2 spore scars very near or almost at tip, 3–4.5 × 15–40 μ; conidia obclavate, subhyaline or almost colored, base short to long obconically truncate, straight to slightly curved, tip blunt, 1–4 septate, 4–6 × 20–50 μ.

Hab.: On leaves of *Cercis canadensis* in Stillwater, Oklahoma, August 1939.

Type: In the herbarium of the Department of Plant Pathology, Cornell University, No. *29235*.

4. **Cercospora Psoraleae** sp. nov.

Maculae orbiculares, 0.5–2.5 mm. diametro, caliginoso-brunneis, supera marginibus angustis elevatis; fungus epiphyllus; plerumque stromatis solum cellis paucis, hyphas conidiferas dense fasciculatas gerentibus, caulis 2–10, per occasionem tot 30; conidiophoris mediocriter atrofuligeneis ad bases sed superne pallescatis attenuatisque, pluriseptatis, rectis vel curvatis, raro semel geniculatis, non-ramosis, ad apices rotundatis vel subtruncatis, 4–5.5 × 20–140 μ; conidiis hyalinis, acicularis, rectis vel nonnihil curvatis, pluriseptatis, septis inconspicuis, ad bases truncatis, ad apices subobtusis, 2–4 × 20–100 μ.

Hab. in foliis *Psoralea digitata*.

Leaf spots circular, 0.5–2.5 mm. in diameter, dull brown, on upper surface with raised line border; the stromata mostly only a few dark cells, giving rise to fascicles of usually 2–10 stalks, but occasionally as many as 30; conidiophores medium dark fuligenous near base, paler and more narrow toward tip, multiseptate, straight to curved, rarely once geniculate, not branched, medium spore scar at rounded to subrtuncate tip, 4–5.5 × 20–140 μ; conidia hyaline, acicular, straight to slightly curved, indistinctly multiseptate, base truncate, tip subobtuse, 2–4 × 20–100 μ.

Hab.: On leaves of *Psoralea digitata* in Stillwater, Oklahoma, July 1940.

Type: In the herbarium of the Department of Plant Pathology, Cornell University, No. *29233*.

The following species, which have been deposited in the Cryptogamic Herbarium at the Oklahoma A. and M. College, have been collected in Oklahoma during the past several years by the author:

5. CERCOSPORA ACALYPHAE Peck.

On *Acalypha ostryaefolia* Rid., Stillwater, Aug. 18, 1939, No. 256.

6. CERCOSPORA ANTHELMINTICA Atk.

On *Chenopodium hybridum* L., Ripley, Sept. 23, 1939, No. 244.

7. CERCOSPORA ASPARAGI Sacc.

On *Asparagus officinalis* L., Perkins, Oct. 1938, No. 14.

8. CERCOSPORA CRUENTA Sacc.
On *Vigna sinensis* (L.) Endl., Berwyn, Aug. 13, 1938, No. 288.

9. CERCOSPORA DUBIA (R.) Wint.
On *Chenopodium album* L., Stillwater, July 3, 1940, No. 1505.

10. CERCOSPORA FLAGELLARIS Ellis & Martin.
On *Phytolacca decandra* L., Stillwater, Aug. 14, 1939, No. 269.

11. CERCOSPORA GAURAE Kellerm. & Swingle.
On *Gaura biennis* L., Stillwater, Aug. 18, 1939, No. 214.

12. CERCOSPORAE HYDRANGEAE Ellis & Ev.
On *Hydrangea arborescens* L., Stillwater, Aug. 19, 1939, No. 248.

13. CERCOSPORA OCULATA Ellis & Kellerm.
On *Vernonia Baldwini* Torr., Stillwater, Aug. 18, 1939, No. 257.

14. CERCOSPORA PACHYPUS Ellis & Kellerm.
On *Helianthus annuus* L., Stillwater, Aug. 21, 1939, No. 247.

15. CERCOSPORA PETUNIAE Mull. & Chupp.
On *Petunia hybrida* Vilm., Stillwater, July 9, 1940, No. 1545.

16. CERCOSPORA SQUALIDULA Peck.
On *Clematis Pitcheri* T. & G., Stillwater, June 29, 1940, No. 1475.

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THE DISTRIBUTION AND ASSOCIATION OF GONATORRHODIELLA HIGHLEI WITH NECTRIA COCCINEA IN THE UNITED STATES

THEODORE T. AYERS [1]

(WITH 1 FIGURE)

INTRODUCTION

Gonatorrhodiella Highlei A. L. Smith, one of the rarer members of the Fungi Imperfecti, is interesting not only because of its unusual morphology, but because of its close association with *Nectria coccinea* (Pers.) Fries,[2] one of the organisms involved in the beech bark disease (**3**) in North America. The growth of this fungus with *N. coccinea* is especially notable because *G. Highlei* was discovered growing originally on onion bulbs in England (**7**).

The first American collection of *Gonatorrhodiella Highlei* was made, as far as can be determined, by Dr. Haven Metcalf and Dr. Rush P. Marshall, who found it growing in association with *Nectria coccinea* and the scale insect (*Cryptococcus Fagi* (Baer.)) on beech trees (*Fagus grandifolia* Everhart) near Perry, Maine, in 1933. Collections made at that time were submitted to the writer for identification.

Subsequent observations made by the writer in different sections of Maine showed that *Gonatorrhodiella Highlei* growing on beech trees attacked by *Nectria coccinea* and *Cryptococcus Fagi* formed unusually conspicuous, irregular patches consisting of vegetative and fertile hyphae, the latter being cinnamon-buff to clay or rarely tawny [3] in color. These patches, which range from a

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[2] The specific name *Nectria coccinea* is used here, although Ashcroft (**1**) has pointed out that the species of *Nectria* implicated in the beech bark disease agrees with the type material of *Nectria ditissima* Tul. and Fries has depicted *N. coccinea* as having elongated-filiform ascospores.

[3] Ridgway, R. Color Standards and Color Nomenclature, Washington, D. C. 1912.

few square millimeters to several square centimeters in area, may be confined to a small section of the tree or they may be distributed intermittently or continuously up the tree as high as 10 meters above ground, virtually covering the side of the tree attacked by *N. coccinea*. In fact, the presence of *N. coccinea* on a tree may be detected readily because of the color of *G. Highlei*.

Since a review of the literature has shown that *Gonatorrhodiella Highlei* has not been previously reported in American mycological literature and because of its association with *Nectria coccinea*, one of the organisms responsible for the beech bark disease (**3**) in North America, the first report of the presence of this organism in the United States is herein given, and attention is called to the differences between it and other species of the genus *Gonatorrhodiella*, especially *G. parasitica*. This latter species collected originally in Connecticut was described by Thaxter (**8**) as a monotypic species of a new genus and is the only species of this genus heretofore reported from North America.

COMPARISON OF GONATORRHODIELLA HIGHLEI WITH OTHER SPECIES OF THE SAME GENUS

A comparison of *Gonatorrhodiella Highlei* with type material of *G. parasitica* showed that these two species differ chiefly in their morphological characters. In *G. Highlei* microscopic examination showed that the nodal sporiferous cells, designated as basal cells by Thaxter (**8**) and primary conidia by Smith and Rea (**7**), attached to the subspherical or ellipsoidal terminal or intercalary swellings of the conidiophores are obovate or pyriform (FIG. 1 B, F) and are larger in diameter than the components of the conidial chains, while the nodal cells of *G. parasitica* are elliptical and about equal in diameter to the conidia borne by them. Instead of a single, simple conidial chain attached to each nodal cell, as in *G. parasitica*, the obovate or pyriform nodal cells of *G. Highlei* bear usually three chains of conidia (FIG. 1 F), which in turn bud off spores laterally, thus forming a complex chain of conidia. These two organisms differ macroscopically also. For example, the conidiophores of *G. parasitica* were reported by Thaxter (**8**) to be about 1 mm. in height while those of *G. Highlei* from the writer's collections were found to be .2–.4 mm. in height. Furthermore, an examination of

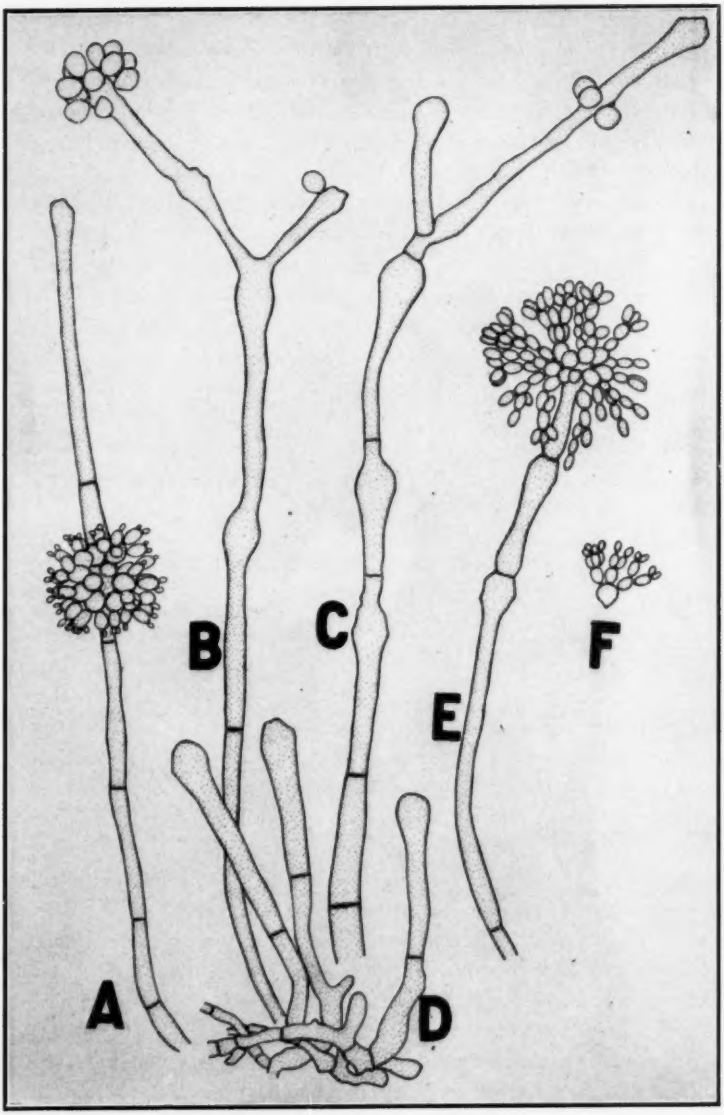

FIG. 1

the available collections of these two fungi showed that *G. Highlei* growing on *N. coccinea* in artificial culture as well as in nature was cinnamon buff, clay, or rarely tawny in color (Ridgway), while *G. parasitica* was cinnamon-rufous (Ridgway) when cultivated on *Trichoderma lignorum* (Tode) Harz growing on agar media. Never having collected *G. parasitica* in the field, the writer used as a comparison, cultures of *G. parasitica* obtained from Ross W. Davidson, who isolated this fungus together with *Trichoderma lignorum* (Tode) Harz from a malformed sporophore of *Polyporus* sp., and from river birch (*Betula nigra* L.) decayed by *Fomes* sp. Because he was unable to culture the *Gonatorrhodiella* in the absence of *T. lignorum,* Davidson (Plant Disease Reporter XIX, No. 7 1935) believed that *G. parasitica* was parasitic on it.

A species growing on *Tremella lutescens* Pers. was collected by von Hoehnel (**4**) in Europe and described by him as *Gonatorrhodiella eximia.* In comparing type material of this species with that of *G. parasitica,* the writer found no marked differences between these two species and therefore considers the names to be synonyms for the same fungus. On the other hand, a comparison of the description and illustrations of collections of *G. Highlei* made in England and collections of this fungus from North America with authentic material of *G. eximia,* showed that they are distinct species. It is interesting from the standpoint of geographical distribution of fungi that there are two distinct species, *G. parasitica* and *G. Highlei,* distributed in both North America and Europe.

A fungus found growing on scale insects was described by Petch (**5**) as a new species of this genus, *Gonatorrhodiella coccorum.* However, the description and illustrations prepared by him for this fungus do not agree with either *G. Highlei* or *G. parasitica.* In fact, no characters could be found in either the descrip-

FIG. 1. A, young conidiophore of *Gonatorrhodiella Highlei* with a terminal head and an intercalary swelling; nodal cells were still attached to the intercalary swelling; B and C, branched conidiophores with several intercalary swellings; some obovate nodal cells are still attached to the terminal heads of the conidiophore in B; D, young conidiophores prior to the formation of intercalary swelling; E, portion of a conidiophore with several chains of conidia (note the difference in size between nodal spore-bearing cells and conidia); F, nodal spore-bearing cell with three chains of conidia.

tion or illustrations of *G. coccorum* that would warrant placing it in the genus *Gonatorrhodiella*. Although he described it as a species of *Gonatorrhodiella,* Petch made the following statement, "Consequently it is doubtful whether this species is correctly referred to *Gonatorrhodiella*."

Inasmuch as this study of *Gonatorrhodiella Highlei* and comparison of it with other reported species of the same genus have added to our knowledge of its morphology and distribution, it was deemed desirable to amend its original description.

TECHNICAL DESCRIPTION OF GONATORRHODIELLA HIGHLEI A. L. SMITH DESCR. EMEND.

Sterile hyphae hyaline, creeping, septate and branched; conidiophores erect (FIG. 1 A, D), 200–400 μ in height, 12–15 μ in diam.; septate, hyaline, becoming cinnamon buff to clay or rarely tawny in color; simple or rarely branched, swelling into subspherical to ellipsoidal heads, which after maturity may become once or twice proliferous; the proliferations, 18–27 μ in diam., also forming similar proliferating heads, seldom more than five times successively proliferous (FIG. 1 B, C). The conidia, 14–17 $\times$ 9–11 μ, are elliptical and borne in complex trigeminous chains on obovate, nodal cells (FIG. 1 E, F) 16–19 $\mu \times$ 11–17 μ.

Habitat: Associated with *Nectria coccinea* (Pers.) Fries growing with the beech scale (*Cryptococcus Fagi* (Baer.)) on beech (*Fagus grandifolia* Ehrhart) in Maine, North America. Collected originally on onion bulbs in England.

Specimens examined: Collections of *Gonatorrhodiella Highlei,* associated with *Nectria coccinea* and *Cryptococcus Fagi* on beech (*Fagus grandifolia*), were made at least once in the following localities: Maine: *63938,*[4] Perry, T. T. Ayers, Oct. 1933; *67862,* Perry, H. Metcalf and R. P. Marshall, July 27, 1933; *67768,* Liberty, T. T. Ayers, June 28, 1935; *69697,* Liberty, M. L. Lohman, November 15, 1935; *81555,* Topsfield, T. T. Ayers, September 28, 1937; *81556,* Township 22 M. D., T. T. Ayers, September 30,

[4] Numbers, unless otherwise indicated, refer to collections in the herbarium of the Division of Forest Pathology, U. S. Department of Agriculture, New Haven, Conn.

1937; *81557,* Township 39 M. D., T. T. Ayers, September 30, 1937; *81558,* Perry, T. T. Ayers, September 30, 1937.

Doubtful specimen: *Gonatorrhodiella* sp. on *Melannoma pulvis-pyrius* growing on axe chip from *Ulmus americana* L., Indian Town, Maine, H. Eno, October 15, 1936. This form is close to *G. Highlei* but varies slightly from it in morphological characteristics. Further study is necessary before a definite statement can be made concerning its identity.

SPECIMENS OF GONATORRHODIELLA PARASITICA AND G. EXIMIA EXAMINED

The type specimen of *Gonatorrhodiella parasitica* Thaxter, Oct., New Haven, Conn., on *Hypocrea chlorospora.* This specimen is labelled as "type" in Thaxter's handwriting on a pill box containing his collection and is deposited in the herbarium of the Connecticut Agricultural Experiment Station, New Haven, Conn.

Type slide of *Gonatorrhodiella parasitica* deposited in the Farlow Herbarium, Harvard University, Cambridge, Mass.

Cultures of *Gonatorrhodiella parasitica* isolated by Ross W. Davidson (Plant Disease Reported XIX, No. 7, 1935) together with *Trichoderma lignorum* from tissue of malformed sporophores of *Polyporus* sp. (F. P. *59146*) and from river birch decayed by *Fomes* sp.

The type specimen and slide of *Gonatorrhodiella eximia* von Hoehnel deposited in the Farlow Herbarium, Harvard University. Labelled as "H.n. 433 *Gonatorrhodiella eximia* n. sp. Auf *Tremella lutescens* y Carpinus. 23/7.1906. v. Hoehnel, Wiener Wald."

ASSOCIATION OF GONATORRHODIELLA HIGHLEI WITH NECTRIA COCCINEA IN THE UNITED STATES

It is difficult to explain why *Gonatorrhodiella Highlei* has been collected so far in the United States upon only one species of fungus, *Nectria coccinea,* which is considered by some investigators to have been introduced into North America from Europe. Many different species of *Nectria* and other closely related fungi have been collected by numerous investigators throughout New England and New York, but as far as could be learned, *G. Highlei* has never

been found associated with any of them. Furthermore, *G. Highlei* failed to appear in the numerous cultures isolated from the perithecia of these different species of *Nectria* and from cankers with which *Nectria* species were associated. It appeared frequently, however, in cultures isolated from perithecia of *Nectria coccinea* associated with the beech bark disease, and in cultures made from the tissues of beech trees attacked by the same disease. Because of the close association of *G. Highlei* with this particular species of *Nectria,* and the fact that it grows so meagerly when alone on media commonly used for the cultivation of fungi, this fungus appears to be either parasitic or dependent on *Nectria coccinea* for its nutrition. So far, however, no haustoria have been observed in the hyphae of *N. coccinea,* and no other organs to enable *G. Highlei* to act as a parasite have been determined. Similarly, the manner in which *G. parasitica* parasitizes *Hypomyces* sp. and *Hypocrea* sp. was not described by Thaxter (**8**) although he considered it to be a parasite on these two fungi. He did not report whether he had attempted to cultivate *G. parasitica* without a host on artificial media. Davidson (loc. cit.), however, stated that "An attempt to obtain this fungus [*G. parasitica*] in pure culture failed, although the *Trichoderma* was readily obtained free from the *Gonatorrhodiella. Trichoderma* grows more rapidly than *G. parasitica,* usually covering the entire surface of the agar with a green spore mass before the parasite appears. *G. parasitica* grows slowly over the surface of such a culture and gradually covers it with a 'tawny' red mass of conidiophores and spores."

GROWTH OF GONATORRHODIELLA HIGHLEI IN ARTIFICIAL CULTURE

Initial attempts to obtain pure cultures of *Gonatorrhodiella Highlei* on such common media as potato, potato-dextrose, oatmeal, and malt extract agars were not highly successful, but the fungus grew luxuriantly and produced an abundance of conidiophores on the same media when *Nectria coccinea* was present. Since *G. Highlei* grew so poorly on media containing agar, and because other species of fungi parasitic on insects (**6**) and on other fungi (**2**) were found to grow poorly when agar was included in the culture medium, an attempt was made to cultivate *G. Highlei* on substrata without it.

To secure pure cultures of *Gonatorrhodiella Highlei,* single-spore isolations were used at first. However, these conidia failed to germinate on the different media used and even to date the conditions necessary for their germination have not been discovered. Therefore, fragments of the fertile conidiophores were used. These were removed with a fine platinum needle and planted on the agar media. As negative or very slow growth would indicate pure cultures of *G. Highlei* (without *N. coccinea*) the cultures were observed carefully for at least 10 days before they were transferred to the different substrata which were tested as suitable for the growth and sporulation of *G. Highlei.*

As a result of these cultural experiments it was found that *Gonatorrhodiella Highlei* could be grown successfully in pure culture on oatmeal mush (20 grams of oatmeal, 60 cc. of distilled water; autoclaved for 20 minutes at 15 pounds' pressure). On this medium, the fungus grew slowly and covered the surface of the medium within a month, producing an abundance of normal fertile conidiophores. On potato plugs, cooked rice and synthetic malt agar,[5] it produced a trace of vegetative mycelium and a few conidiophores. It formed no conidiophores and only a trace of vegetative growth on potato, potato-dextrose, malt extract, 1% maltose, 1% sucrose, 1% dextrin, 1% proteose-peptone and peptone agar media.

It is interesting to note that this fungus grew and produced numerous fertile conidiophores on these latter media when *Nectria coccinea,* associated with the beech bark disease, *Nectria galligena* Bres. concerned with cankers on various hardwoods, or *Nectria cucurbitula* (Tode) Fries, from conifers was growing in the same tubes. *G. Highlei* failed to grow, however, when either *Nectria cinnabarina* (Tode) Fries, or *N. Coryli* Fuckel was cultured on these same media.

SUMMARY

The presence and distribution of *Gonatorrhodiella Highlei* A. L. Smith, one of the rarer members of the Fungi Imperfecti collected

[5] Formula No. 1579 in Levine, M., and H. W. Schoenlein. A compilation of culture media for the cultivation of microorganisms. Baltimore, Md., 1930.

originally in England on onion bulbs, are reported for the first time in the United States.

G. Highlei is particularly interesting not only because of its unusual morphology, but also because of its association with *Nectria coccinea,* which together with *Cryptococcus Fagi* is concerned with the beech bark disease of our native beech (*Fagus grandifolia*) in New England.

A comparison of *Gonatorrhodiella Highlei* was made with *G. parasitica* and other species of this genus. As a result of these studies, it was concluded that at present there are only two valid species of *Gonatorrhodiella, G. parasitica* and *G. Highlei,* known. Two other species have been described, but *G. eximia* seems to be synonymous with *G. parasitica,* while *G. coccorum* is not a member of the genus.

Gonatorrhodiella Highlei produced only a scant mycelial growth and a few conidiophores on synthetic malt and only a trace of vegetative growth on potato, potato-dextrose, and malt agars. But it grew luxuriantly and produced an abundance of conidiophores on a medium consisting of 20 grams of oatmeal and 60 cc. of distilled water.

When planted with *Nectria coccinea, N. galligena,* or *N. cucurbitula* on potato, potato-dextrose, or malt-extract agar, *Gonatorrhodiella Highlei* grew abundantly and produced numerous fertile hyphae. It failed to grow, however, when it was planted on the same media with either *N. Coryli* or *N. cinnabarina.*

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LITERATURE CITED

1. **Ashcroft, J. M.** European canker of black walnut and other trees. W. Va. Agr. Exp. Sta. Bull. **261**: 1–51. 1934.
2. **Ayers, T. T.** Growth of *Dispira cornuta* in artificial culture. Mycologia **25**: 333–341. 1933.
3. **Ehrlich, J.** The beech bark disease. A *Nectria* disease of *Fagus,* following *Cryptococcus Fagi* (Baer.). Can. Jour. Res. **10**: 593–692. 1934.
4. **Hoehnel, F. X. R. von.** Fragmente zur Mykologie. Sitz-ber. Akad. Wien **66**: 146. 1907.

5. **Petch, T.** Studies in entomogenous fungi. VI. *Cephalosporium* and associated fungi. Trans. Brit. Myc. Soc. **10**: 152–182. 1925.
6. **Sawyer, W. H., Jr.** Observations on some entomogenous members of the Entomophthorales in artificial culture. Am. Jour. Bot. **16**: 87–121. 1929.
7. **Smith, A. L., & Rea, Carlton.** New and rare British fungi. Trans. Brit. Myc. Soc. **3**: 36. 1908.
8. **Thaxter, R.** On certain new or peculiar North American Hyphomycetes II. *Helicocephalum, Gonatorrhodiella, Desmidiospora* nov. genera and *Everhartia lignatilis* n. sp. Bot. Gaz. **16**: 201–205. 1891.

THE DEVELOPMENT OF A SPECIES OF COPRINUS

G. T. JOHNSON

(WITH 9 FIGURES)

INTRODUCTION

Schmitz (**1842**), Hoffmann (**1861–1865**), de Bary (**1866**), Brefeld (**1877**), Levine (**1914, 1922**), Atkinson (**1916**), Kühner (**1926**), and Chow (**1931, 1932, 1934**) have reported developmental studies of species of *Coprinus*. All of these have agreed that the hymenium is endogenous in origin, that the pilear and stipe primordia are differentiated almost simultaneously very early in development, and in several other details of considerable importance. Reports as to the formation of an annular prelamellar cavity and as to the manner of origin of primary and secondary lamellae differ so greatly, however, that further evidence is required before any claim can be held substantiated. The proper interpretation of these developmental processes is necessary so that a safer basis may be provided for phylogenetic considerations of the Agaricaceae. In this paper the writer records observations on the development of a species of *Coprinus* not previously studied, and in this connection particular attention is given to those details in development over which controversy has arisen.

MATERIALS AND METHODS

The material studied was isolated in 1936 from a sample of Costa Rican soil placed on sterile agar by Dr. C. W. Dodge. The organism subsequently proved readily adaptable for physiological study, since at the time of its isolation a generation of fruit bodies could be produced in nine days on potato-dextrose agar under the proper environmental conditions. Mature specimens fall rather easily into *Coprinus cubensis* Berk. & Curt. according to most of the artificial keys that could be constructed for the genus, but apparently differ from typical material of that species in possessing

brownish rather than whitish scales and slightly more oval spores. A description of the plant follows:

Stipe 1.5–10.0 cm. long, 2–5 mm. thick, equal or slightly attenuated, glabrous, hollow, white, cartilaginous; pileus 1.5–3.5 cm. broad, very thin, campanulate, striate at maturity, grayish, ornamented with brownish scales which partially disappear with age; gills crowded, thin, free, white when young, finally brownish-black, with numerous cystidia; cystidia attached to either or to both gills, 16–49 μ long, 14–24 μ wide, subspherical to cylindrical; basidia 11–16 μ long, 4–6 μ wide, 4-spored; spores 6–7 $\times$ 3–4 μ, smooth, brown to black.

SPECIMENS DISTRIBUTED: G. T. Johnson *n. 625*. Isolated from soil collected at Castilla, Limón Province, Costa Rica.

Sporophores were obtained at varied intervals from flask cultures grown in the laboratory on potato-dextrose agar. The mature fruit bodies were normal in every respect, and in view of the ease with which the organism fruits in culture when isolated from nature there is little reason to suppose that the specimens obtained would present different characters if grown in their native habitat. Plants in every stage of development were selected, killed in Flemming's weaker solution, embedded in paraffin, sectioned, stained, and mounted in balsam.

DEVELOPMENT OF THE ORGANISM

The germ tube emerges from one end of the basidiospore. A single nucleus is present in the mature spore and this soon divides, the two resulting daughter nuclei migrating into the germ tube. As the tube grows and branches, division continues and a large number of free nuclei are finally produced. Septa are not formed for some time after germination. When they do occur no clamp connections are visible and the hyphal cells usually appear multinucleate. Large numbers of oidia may be produced. Clamp connections have never been observed, regardless of the age of the culture.

Buttons are formed laterally on rhizomorph-like clusters of hyphae. Some differentiation has taken place in the earliest stage of development observed by the writer (FIGS. 1, 2). At this stage the center of the button is composed of very compact hyphae; this

mass is the primordium of the fruit body proper. Hyphae of the outer portion terminate in large globose cells which completely surround the button. These cells persist until maturity, when they are gradually shed in the form of " squamules "; they compose the first differentiated tissue, the " blematogen " as defined by Atkinson (**1914, 1916**).

Stipe, pilear, and hymenial primordia have almost simultaneous origin. The pilear fundament is the most conspicuous, marked by the compact arrangement of hyphae located just below the blematogen in the upper portion of the button. Hyphae of the stipe fundament become loosely interwoven and oriented predominantly in a vertical direction. Pileus and stipe remain in the primordial stage during the formation of the lamellae.

An annular prelamellar cavity can be seen in sections of material of the proper stage killed with Flemming's weaker solution and embedded in paraffin. The cavity develops just below the pilear primordium. In figure 3 it is seen in median section as two clear areas on either side of the young stipe. The hymenial primordium, which was visible as darker staining tissue before the cavity was formed, is now clearly delimited on the upper surface of the cavity. This evidence as to the formation of the cavity agrees with statements of Atkinson (**1916**) but differs from those of Levine (**1914**) for species of *Coprinus*. In 1922 Levine redescribed the method of development that he gave in 1914 (which had been vigorously opposed by Atkinson) as typical of the *Coprini*. Furthermore, he disagreed with the manner of origin of lamellae described by Atkinson, not only for species of *Coprinus* (Atkinson, **1916**) but also for *Agaricus campestris* (Atkinson, **1906**). In Levine's later (**1922**) paper the annular prelamellar cavity mentioned by others and illustrated by figures similar to figure 3 was considered an artifact due to poor fixation. Kühner (**1926**) claimed to have confirmed the method of gill formation described by Levine, but Chow (**1934**), in an extensive memoir on *Coprinus*, supported Atkinson's view and reported that later work by Kühner (unpublished) also did so. It should be noted that Hein (**1930**) has confirmed Atkinson's description of the origin of the lamellae in *Agaricus campestris*.

Observations on this Costa Rican material suggest the following: (1) Atkinson (**1916**) was correct in describing an annular prelamellar cavity from the examination of normal fixed material. Even Levine (**1922**) admitted this point, although his earlier

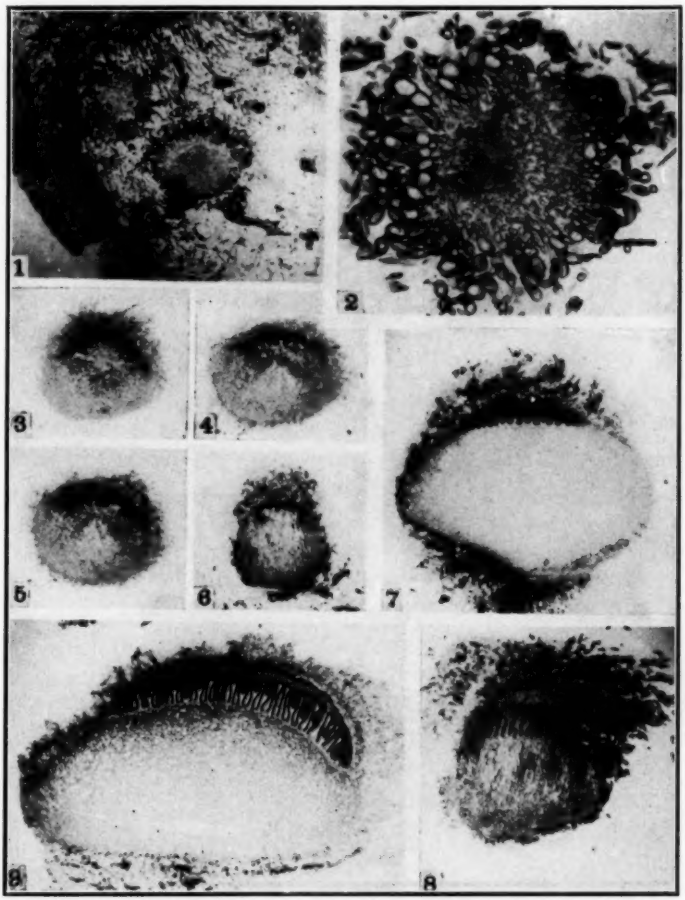

FIG. 1, two sporophore primordia; 2, sporophore primordium; 3–5, young sporophores with normal lamellar development; 6 and 8, young sporophores with abnormal lamellar development; 7 and 9, sporophores more advanced in development. Magnifications approximately as follows: fig. 2 × 200; all others × 50.

(**1914**) paper, during the preparation of which he evidently did not see such a cavity, was based upon material killed by similar reagents. (2) Levine (**1922**) finds strong support for his theory, that the lamellae ultimately develop on each side of a series of gill cavities, in sections of dead buttons. In culture very few buttons finally produced sporophores. There is no doubt but that Levine's description applies to a large number of these cases. Their structure appears quite different from that of similar material fixed in the living condition and an annular prelamellar cavity is never formed. Figures 6 and 8 illustrate the structure of such buttons in vertical section. The plants from which these sections were made were removed from agar cultures fifteen days old on which the buttons had been visible since the sixth day. Several mature fruit bodies had been produced by the same cultures. In normal buttons, however, the lamellae develop shortly after the formation of the annular prelamellar cavity (FIGS. 4, 5, 7, 9). Atkinson emphasized the fact that the trama of the lamellae is formed from tissue growing down from the pilear fundament into the lamella. This does occur, and it gives collaborative support to the opinion that an annular cavity normally exists in species of *Coprinus*.

Other changes now take place: (1) the lamellae grow toward the bottom of the cavity and become loosely attached to the stipe; (2) the hyphae in the stipe primordium form compact vertical rows of very short cells; (3) a single layer of highly differentiated cells is formed just below the upper blematogen; (4) the central portion of the stipe autolyses and that structure is, therefore, hollow at maturity.

All elements increase in size simultaneously. Growth of the stipe is exceedingly vigorous, taking place primarily through elongation of the primordial cells. The expansion bursts the blematogenous layer and the plant assumes the appearance of a mature sporophore, with its hymenium exposed to the air. The blematogen breaks up into small flocculent masses which are gradually shed from the outer pilear surface. Spores are formed and the lamellae deliquesce in the manner typical of species of *Coprinus*.

DISCUSSION

According to Atkinson there are two general patterns of development through which lamellae endogenous in origin are formed. In one of these (the *Agaricus* type) the lamellae arise as downward folds of an annular prelamellar cavity; in the other (the *Amanita* type) a series of gill cavities is produced, hymenial elements being formed on the sides of each cavity. Both Levine (**1922**) and the writer have observed sections of young buttons of *Coprinus* which indicate that conditions simulating either type of development may be present in one species. If, as Atkinson implies, the two types of development are so distinct as to indicate phylogenetic lines, it is important that extreme care be taken in interpreting sections of material of this kind. In the species of *Coprinus* which he has studied the writer believes that an annular prelamellar cavity is formed in the buttons that give rise to mature sporophores, but that abnormalities in development often result. In the abnormal cases such a cavity is never formed, and the buttons in section often appear similar to those from which Atkinson described the "*Amanita*" type of development. The possibility that similar observations could be made on other genera and species should be borne in mind.

Coprinus tomentosus Fries (Chow, **1932, 1934**) is evidently the only investigated species to which the organism studied is closely related. Both lack clamp connections and have the ability to fruit in single spore culture. Furthermore, striking similarities may be seen in the arrangement of the cystidia and in the manner of development of the sporophore.

SUMMARY

(1) This paper describes the developmental morphology of a species of *Coprinus* close to, if not identical with *C. cubensis*. The organism was isolated from Costa Rican soil and is particularly adaptable for physiological study.

(2) At the time of its isolation from natural conditions this organism will fruit in flask cultures on potato-dextrose agar in nine days under the proper environmental conditions.

(3) Stages in the development of the fruit body are similar to those of other investigated species of the genus.

(4) Examination of the buttons that would have produced typical sporophores reveals an annular prelamellar cavity and the lamellae of such buttons originate in the manner described by Atkinson for other *Coprini.*

(5) Some of the buttons that never mature in agar cultures apparently do not form an annular prelamellar cavity and lamellae are not differentiated in the same manner as in the normal button. The writer believes that these are abnormalities which have resulted from the conditions that failed to bring about the production of normal sporophores.

(6) The developmental study of this species indicates its close relationship to *Coprinus tomentosus.*

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LITERATURE CITED

Atkinson, G. F. 1906. The development of *Agaricus campestris.* Bot. Gaz. **42**: 241–264. *6 pls.*

——. 1914. Homology of the "universal veil" in *Agaricus.* Myc. Centralbl. **5**: 13–19. *3 pls.*

——. 1916. Origin and development of the lamellae in *Coprinus.* Bot. Gaz. **61**: 89–130. *6 figs. 8 pls.*

Bary, A. de. 1866. Morphologie und Physiologie der Pilze, Flechten, und Myxomyceten. xii + 316 pp. *101 figs. 1 pl.* Leipzig.

Brefeld, O. 1877. Botanische Untersuchungen über Schimmelpilze. III. Basidiomyceten I. 1–226. *11 pls.* Leipzig.

Chow, C. H. 1931. Sur le développement du carpophore chez *Coprinus tomentosus.* Compt. Rend. Acad. Sci. Paris **192**: 1121–1123.

——. 1932. Le cycle évolutif de *Coprinus tomentosus* Fries ex Bulliard. Le Botaniste **24**: 187–214. *3 pls.*

——. 1934. Contribution à l'étude du développement des Coprins. *Ibid.* **26**: 89–232. *16 figs. 12 pls.*

Hein, I. 1930. Studies on morphogenesis in *Agaricus* (*Psalliota*) *campestris.* Am. Jour. Bot. **17**: 882–915. *4 pls.*

Hoffmann, H. 1861–65. Icones analyticae fungorum. Abbildungen und Beschreibungen von Pilzen mit besonderer Rücksicht auf Anatomie und Entwickelungsgeschichte. 105 pp. *24 pls.* Giessen.

Kühner, R. 1926. Contribution à l'étude des Hyménomycètes et spécialement des Agaricacés. Le Botaniste **17**: 1–224. *37 figs. 4 pls.*

Levine, M. 1914. The origin and development of the lamellae in *Coprinus micaceus*. Am. Jour. Bot. **1**: 343–356. *2 pls.*

——. 1922. The origin and development of lamellae in *Agaricus campestris* and certain species of *Coprinus*. *Ibid.* **9**: 509–533. *12 figs. 8 pls.*

Schmitz, J. 1842. Mycologische Beobachtungen, als Beiträge zur Lebens- und Entwickelungsgeschichte einiger Schwämme aus der Klasse der Gasteromyceten und Hymenomyceten. Linnaea **16**: 141–215. *2 pls.*

FURTHER NOTES ON FUNGI [1]

S. M. ZELLER

(WITH 17 FIGURES)

Notes and descriptions are presented herewith on several new species of fungi or those deserving special notice at present. These are mostly Gasteromycetes but a new species of *Endogone* is also included.

I wish to thank Mrs. D. P. Rogers for the careful illustrations of some of the new species, and Dr. D. P. Rogers for editing the Latin diagnoses.

1. **Rhizopogon brunnescens** sp. nov.

Fructificationes parvae circa 1–1.5 cm. crassae, subsphericae vel elongatae, superficie hebeti, laevi, coactili, alba vel rosea, cinnamomeo-brunnescenti; fibrillis paucis; peridio 600 μ crasso, strato externo hyphis obscure brunneis implicatis, interne prosenchymate et parenchemati pallido-brunneis intermixtis; gleba alba vel sublutescenti; septis modice crassis; basidiis cylindro-clavatis, 4-sporigeris; sporis anguste ellipsoideis vel oblongis, subhyalinis, 6.8–7.5 × 2.5–3.1 μ.

Fructifications small, 1–1.5 cm. in diameter, subspherical to elongate; surface dull, even, felty, white to pinkish when fresh oxydizing cinnamon-brown; fibrils scanty; peridium duplex, outer layer of dark-brown interwoven hyphae, inner of lighter brown prosenchyma and parenchyma intermixed, 600 μ thick; gleba white and remaining so or only slightly buffy at maturity; septa moderately thick; basidia cylindro-clavate, 4-spored; spores narrowly ellipsoid or oblong, subhyaline, 6.8–7.5 × 2.5–3.1 μ.

In coniferous duff, Horse Camp, Mt. Shasta, California, collected by *Wm. B. Cooke,* July 5, 1939, Nos. *13305* and *13306.*

2. **Rhizopogon villosulus** sp. nov.

Fructificationes parvae, usque ad 1.5 cm. crassae, subglobosae, rhizomorphibus magnis affixae; superficie villosula, molli, brunnea, rimoso-are-

[1] Published as Technical Paper No. *353,* with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany.

olata; peridio tenui, siccitate 32–60 μ crasso, strato externo hyphis magnis, 4–7 μ crassis, laxis, brunneis composito, rimoso, strato interno hyphis compactis hyalinis constito; gleba pallido-brunnea, siccitate luteo-brunnea; locellis parvis, labyrinthiformibus; septis angustis hyphis magnis gelatinosis compositis, paraphysibus obovoideis vel oblongis, gelatinosis, 12–20 × 8–10 μ; basidiis anguste clavatis, 2- vel 4-sporigeris, 14–25 × 3–5 μ, sterigmatibus circa 1–1.5 μ long.; sporis anguste ellipsoideis, subhyalinis, 6–7.5 × 2.2–2.7 μ.

Fructifications small, up to 1.5 cm. in diam., subglobose, from a large rhizomorph; surface soft, slightly villose, brown (bister) when fresh, changing little when dried, often becoming areolate due to the rupture of the outer peridium; peridium very thin, 32–60 μ thick, when dry, duplex, the outer layer of large, 4–7 μ, brown loose hyphae some of which are somewhat erect, sometimes rupturing and exposing the inner layer which is composed of hyaline compactly woven hyphae; gleba light brown, drying buffy brown; cavities small, labyrinthiform; septa narrow, of large highly gelatinized hyphae; paraphyses obovate to oblong, highly gelatinized, 12–20 × 8–10 μ; basidia narrow clavate, 2- and 4-spored, exceeding the paraphyses, 14–25 × 3–5 μ; sterigmata about 1–1.5 μ long; spores narrowly ellipsoid, slightly colored, 6–7.5 × 2.2–2.7 μ.

In duff under conifers, Hat Point along Snake River canyon, 23 miles above Imnaha, Wallowa county, Oregon, *H. M. Gilkey,* July 26, 1939, *type, A. M. Rogers,* July 26, 1939.

3. **Hymenogaster minimus** sp. nov.

Fructificationes minutae, circa 2 mm. crassae, globosae, albidae, colore tinctae locellarum brunnearum per peridium pellucidum se ostentarum; basi sterili parum insigni; peridio circa 80 μ crasso, hyalino, hyphis septatis, 7.5–9 μ crassis, laxe implicatis composito, gleba locellis paucis labyrinthiformibus; basidiis 2- vel 4-sporigeris, clavatis, 10–12 × 5–6 μ, sterigmatibus brevibus; sporis obscure brunneis, tenuiter verrucosis, utriculo hyalino, stricto vestitis, lato-ellipsoideis, apiculo parvo, 14–16.3 × 11.5–13 μ.

Fructifications tiny, about 2 mm. in diameter, globular, translucent whitish, with the dark-brown color of the spores showing through from the cavities within and more whitish over the septa of the gleba; peridium about 80 μ thick at the thinnest places when fresh, hyaline, a mesh-like network of septate hyphae, 7.5–9 μ in diameter; sterile base barely apparent as a translucent spot below; no columella or main veins apparent; gleba made up of several labyrinthiform cavities; basidia 2- and 4-spored, clavate, 10–12 × 5–6 μ; sterigmata very short; spores very dark-brown (umber), finely verrucose, covered with a closely applied, hyaline utricle, broadly ellipsoid with a small apiculus, 14–16.3 × 11.5–13 μ.

In coniferous duff, along Trout Creek (tributary to Molalla River), Clackamas county, Oregon, *Beulah G.* and *Helen M. Gilkey,* June 16, 1939, type (in Zeller Herb.).

Hymenogaster minimus is slightly larger than *Gasterella lutophila* and the spores are similar in ornamentation. However, the spores of *Gasterella* are rougher and are without the utricle. The fructifications of *H. minimus* are so small and translucent that the orientation of all cavities and other parts may be observed when halves in water are examined under a low power binocular. The gleba has about 6–14 labyrinthiform cavities, irregular in shape and arrangement. In this latter respect *H. minimus* differs from *Gasterellopsis* Routien, which is about the same size but in which the cavities are arranged symmetrically around a columella as an axis, similar to the carpels of "Cheeses" (*Malva rotundifolia*).

4. HYMENOGASTER REMYI Zeller & Dodge.

Recently the collection of fresh specimens of this species came to us from Wm. B. Cooke, on Mt. Shasta, California. As soon as we saw the spores of the Shasta material we were reminded of the type from the high Alps of Europe. An actual study again of the type, which was kindly loaned from the Farlow Herbarium by Dr. D. H. Linder, shows them to be identical, but fresh material shows also some characters not seen in dry material. An emended description follows:

Fructifications depressed-globose, 2.5–3 cm. broad, 1.5–1.7 cm. high, dingy pale yellow, drying whitish or isabelline, surface smooth, dull, fibrils not evident and no sterile base; peridium 410–460 μ thick, drying 100–270 μ, composed of large compact, or loosely interwoven, thin-walled, hyaline hyphae, about 10–14 μ in diameter; gleba Argus brown to Brussels brown; septa stupose, 30–35 μ thick, hyaline, somewhat gelified; cavities medium size; basidia clavate to pyriform, 4-spored; spores obovoid, rounded above, with a loosened utricle and verrucose, with distal end quite warted and appearing "crowned" under low power microscope, smooth to slightly wrinkled on sides, young spores smooth, obovoid to almost spherical, 8–11 $\times$ 5.5–7.5 μ.

In duff under a log of *Abies magnifica* var. *shastensis,* elevation 8000 ft., woods northwest of Horse Camp, Mt. Shasta, California.

July 31, 1939, *Wm. B. Cooke,* No. *13376,* and the type collected by *Monseur Remy* at Briançon, France, in 1923. This species should be looked for in other alpine regions.

5. **Dendrogaster elasmomycetoides** sp. nov.

Fructificationes turbinatae, 3–4 cm. crassae, 2.3–3 cm. altae, superne viscidissimae glabraeque, inferne glabrae, albogriseae, siccitate superne pallido-luteae, inferne purpureae, fulvescentes; basi sterili conica sursum in columellam stipitoidem crassam percurrentem procurrenti, extus et intus albida, prosenchymate et parenchymate constita; peridio 260–350 μ crasso, strato externo prosenchymato gelatineo, interno parenchymate collapso composito; gleba luteo-brunneola, locellis parvis, globosis vel labyrinthiformibus; septis reticulato-prosenchymatis, hic illic parenchymate compositis; basidiis anguste clavatis, 4-sporigeris, sterigmatibus circa 2–3 μ longis; sporis brunneis, lato-obovoido-ellipsoideis, verrucosis, utriculo tenui, hyalino, stricto vestitis, 10–11.5 × 8–9.5 μ; textis sterilibus omnibus cum hyphis lactiferis, sed lacte non viso.

Fructifications turbinate or shape of a young agaric before breaking the veil, 3–4 cm. in diameter, 2.3–3 cm. high, greatly shrinking when dry, extremely viscid and even above, smooth below, whitish-gray drying light-buff above, purplish becoming tawny below (FIG. 14); sterile base a conical projection, extended above as a broad percurrent stipe-like columella, whitish within and without, prosenchymatous with islands of parenchyma and hyaline food ducts dispersed; peridium 260–350 μ thick, the outer ½ to ⅔ of which is composed of a gelatinous periclinal prosenchyma and the inner ⅓ to ½ of a more compact (dark staining) collapsed parenchyma (?); gleba slightly more buffy-brownish than the sterile tissues, cavities small, globose to labyrinthiform; septa a meshy prosenchyma, here and there parenchymatous; basidia narrowly clavate, 4-spored; sterigmata about 2–3 μ long; spores brown, broadly obovoid-ellipsoid, verrucose, 10–11.5 × 8–9.5 μ with a thin, almost hyaline, closely applied utricle (FIG. 15); no milk but brown ducts in all sterile tissues.

Two inches under duff of *Abies magnifica* var. *shastensis,* Horse Camp, Mt. Shasta, Siskiyou county, California, *Wm. B. Cooke,* No. *10,216,* type, July 18, 1938. Elevation 8000 ft.

The collector's notes which follow are of interest. "This specimen looked at first like the bud of an agaric of some sort but when I sliced it in two I found it was not. I washed the dirt off and in so doing found that the outer layer became exceedingly viscid and slimy in my hands. At a point where one might say

the stipe ends and the columella begins, or if it were an agaric, where the pileus would eventually break away from the stalk leaving the veil or volva, was an area colored on the outer layers of the fructification with a purple color. The rest of the fructification was rather pallid on the outside, being of a more or less white-gray color. There was no marked coloration inside, no change of color when bruised, no milky exudation."

It is rather perplexing to a taxonomist of the Gasteromycetes to find such a fungus as *Dendrogaster elasmomycetoides*. It could be, by the stretch of imagination, placed in any one of three genera. I am not entirely sure that my choice is the best. Perhaps a less conservative worker would erect a new genus for it. To aid him we might give these additional suggestions. This fungus has the form and some internal morphological characters of *Elasmomyces*. It has the spores of *Hymenogaster*, and although the collector says there was " no milky exudation " when fresh, there are nevertheless a very few very dark-brown ducts in the sterile tissues and it may be that at certain stages of development of the fructifications these ducts are lactiferous. It therefore might be placed in *Arcangeliella* along with *A. Behrii* and its so-called variety *caudata*. The writer, however, has decided in favor of *Dendrogaster* because of the character of the spores, columella, and the fact that the collector indicated no milk when fresh. He is also inclined after more recent study to the transfer of *Arcangeliella Behrii* and its variants to the genus *Dendrogaster*. The more knowledge we have of the Gasteromycetes the more the evolutionary trends within the group become anastomosing lines.

Young spores of *D. elasmomycetoides* are more or less truncate at the distal end with the utricle bulged or blister-like over the flat portion.

6. **Hydnangium oregonense** sp. nov.

Fructificationes 1–2 cm. crassae, depresso-globosae, superficie laevi, albae vel brunnescentes; peridio 110–175 μ crasso, strato externo 35–45 μ crasso, pseudoparenchymato, interno hyphis periclinis et implicatis composito; gleba alba carneo- vel brunneo-rubescenti; locellis parvis; septis hyphis laxis implicatis; cystidiis moniliformibus; basidiis clavatis, 1-sporigeris, 30–37 × 10–12.5 μ, sterigmatibus 18–25 μ longis; sporis subhyalinis, echinulatis, aculeis 2.5–6.3 μ longis, lato-ellipsoideis, 16–17.7 × 14.4–15 μ (sine aculeis); odore farinaceo.

Fructifications 1–2 cm. broad, depressed globose, smooth, white becoming marbled with light and dark-brownish spots; peridium 110–175 μ thick, duplex, outer 35–45 μ of pseudo-parenchyma, inner layer of periclinal and interwoven hyphae; gleba white becoming flesh-pink, then brownish-pink; cavities small; septa of loosely woven hyphae; cystidia moniliform when present, exceeding the paraphyses 13–20 μ; basidia clavate, 30–37 $\times$ 10–12.5 μ, 1-spored; sterigmata long, stout, 18–25 μ long before spore formation, becoming shorter with spore formation; spores almost hyaline, sharply echinulate (echinulae 2.5–6.3 μ long), broadly ellipsoid, 16–17.7 $\times$ 14.4–15 μ without echinulae; odor farinaceous.

Under forest duff in mixed woods, Roaring River Fish Hatchery, Linn county, Oregon, April 30, 1938, *S. M. Zeller, 8487,* type.

This is a most interesting species of *Hydnangium,* closely related to *H. monosporum* Boud. & Pat. It differs from that species, however, in peridial structure and spore characters. In young specimens without spores the moniliform cystidia are very plentiful in certain cavities of a specimen; other cavities will have none. In older stages where spores are just beginning to form certain cavities near the peridium are lined with hymenium having so many mono-sterigmate basidia that they appear setose under the low power microscope. These sterigmata without spores are stout, obtuse, and 18–25 μ long. In cavities near the center of such fructifications where spores are mature these straight seta-like sterigmata are entirely lacking, each bearing a spore.

7. **Hysterangium aureum** sp. nov.

Fructificationes subsphaericae vel depresso-globosae, usque ad 1.3 cm. crassae, firmae, aureae; columella mediam fructificationem attingenti, leviter ramosa; peridio 325–450 μ crasso, non facile separabilibus, parenchymato, cellulis polyedricis usque ad 72 μ crassis extus aureis, intus hyalinis; gleba brunneo-olivacea, locellis magnis, aliquentum e columella radiantibus, vacuis; septis hyalinis, circa 80 μ crassis, gelatinescentibus; sporis ellipsoideis, utroque rotundatis, hyalinis, 11–12.5 $\times$ 5 μ.

Fructifications subspherical becoming depressed-globose, up to 1.3 cm. in diameter, firm, golden-brownish, drying darker; columella reaching to center of fructification, somewhat branched; peridium 325–450 μ thick, not easily separable, parenchymatous, of polyhedral cells up to 72 μ in diam., outer cells golden, inner hyaline, no distinct layer of hyphae separating peridium and gleba; gleba brownish-olivaceous; cavities large, somewhat radiating;

empty; septa hyaline, about 80 μ thick of gelified hyphae; spores ellipsoid, rounded at both ends, hyaline, 11–12.5 $\times$ 5 μ.

Under vine maple and conifers, Trout Creek Recreational Area, Linn county, Oregon; collected by *S. M. Zeller,* No. *8480,* type, May 21, 1936.

8. HYSTERANGIUM CRASSUM (Tul.) Fischer.
(Syn. *H. clathroides* var. *crassum* Tul.)

Fructifications enveloped in a dense spawn of slender white, much branched rhizomorphs, up to 1.8 cm. in diameter, surface white becoming a warm brown, cottony with rhizomorphs and hyphae which adhere everywhere; peridium 70–110 μ thick, easily removed, composed of a layer of compact, heavy-walled prosenchyma of cells up to 6 μ in diameter, overlaid outside with hyphae about 3–3.8 μ in diameter with some clamp-connections and sometimes covered with white crystals, and prosenchyma lined inside with a thin layer of soft parenchyma extremely variable in thickness, extending into interstices of the interrupted tramal peridium; columella much branched; gleba glaucous-virescent, becoming greenish-ashy and even clay-color, very dark-greenish in preservative; septa variable in thickness of intertwined, hyaline hyphae about 3.2 μ in diameter; cavities medium radiating; basidia narrowly clavate, 2–3-spored, early evanescent; spores sessile, olivaceous, fusiform acute or obtuse above, sometimes papillate, epispore thick, 17.5–20 $\times$ 5–6.3 μ; odor unpleasant at maturity.

In a dense spawn 2–4 inches under forest duff. Usually under maple, oak or conifers.

The writer has been interested for a number of years in the habitat and general characters of this species as it occurs under natural conditions. After once seen in the forest soil it cannot be mistaken a second time. The heavy white spawn (so well illustrated by Tulasne, *pl. 2, fig. 2*) is found under the forest duff. It is usually 2–4 inches thick and may spread through the soil for several feet. The spawn may be taken out in large pieces and the fructifications literally "peeled" or "shucked" out of the spawn, which is a compact meshiness of tiny white rhizomorphs and mycelium. It is most usually found in gravelly soil or in mountain soils where there is much rather finely crushed rock.

It is evident this species is not even closely related to *H. separabile* (*H. clathroides* of Tulasne, Hesse, and Zeller & Dodge), and

Fischer (Schweiz. Zeits. Pilzk. **16**: 103–105. 1938) was justified in raising it to specific rank.

Many collections of *H. crassum* particularly from Oregon and California have been examined since those previously cited (Ann. Missouri Bot. Gard. **16**: 97. 1929) but space will not be given here to cite individual collections.

9. **Hysterangium separabile** sp. nov.

Fructificationes 1–1.5 cm. crassae, globosae, albae, brunnescentes; superficie glabra; superne funiculi desunt, inferne inconspicui; columella vulgo magna prominentique, mediam fructificationem attingenti vel a basi ramosa; peridio 220–450 μ crasso, parenchymato, cellulis sphericis vel polyedricis, 12–40 μ crassis strato interno tenui, hyphis parvis, parallelis facile separabilibus composito; gleba viridi, siccata pallide vel obscure virido-olivascenti, locellis parvis, vacuis, polydericis vel irregularibus, aliquentum e columella radiantibus; septis 85–140 μ crassis, hyphis laxe implicatis circa 5–7 μ crassis compositis, gelatin escentibus; basidiis longis, irregulariter cylindericis, 3–4-sporigeris (vulgo 3-sporigeris), sterigmatibus vel brevibus vel 16–18 μ long.; sporis olivaceis, lanceolatis, 12–19 $\times$ 6–8 μ, episporo crasso, subrugoso laxoque, subinde papillatis; maturis odore foetido; sapore grato junioribus.

Fructifications up to 1.5 cm. in diameter, globose, becoming very irregular on drying, white when young becoming pale ochraceous-buff or light ochraceous-salmon when fresh, becoming buff-pink to onion-skin pink where bruised, drying ochraceous tawny to mummy-brown; fibrils none above, but variable from terete and free to innate or appressed below; columella usually large and prominent, reaching half way to apex of fructification or often branching near the base; peridium 220–450 μ thick, parenchymatous, the cells spherical to polyhedral, varying from 12–40 μ in diameter with a very thin filamentous layer between the parenchyma and gleba, easily separable; gleba green when fresh, becoming citrine drab or grayish-olive to dark greenish-olive on drying; cavities polyhedral to irregular, with a tendency to radiate from the columella, small, empty; septa 85–140 μ thick, composed of large, thin-walled, loosely woven hyphae, up to 5–7 μ in diameter, finally becoming highly gelatinized; basidia long, irregularly cylindrical, 3–4-spored (mostly 3-spored); sterigmata usually short, although sometimes becoming 16–18 μ long; spores acrogenous, olivaceous in mass, lanceolate, 12–19 $\times$ 6–8 μ (averaging 15.3 $\pm$ 0.9 μ long), with a thick epispore which sometimes is slightly roughened and becomes loosened in age, sometimes papillate at apex; odor offensive at maturity; taste pleasant when young.

Hypogeous under conifers and deciduous trees and shrubs. It has a wide distribution in the New England States, New York,

Wyoming, Arizona, Oregon, and California; Chile and Argentina in South America, and in Europe.

Hysterangium separabile is the name proposed for that species which has gone erroneously under the name of *H. clathroides* ever since the time of Tulasne.[2] The concept persisted through publication by Hesse, Buckholz, and Ed. Fischer, until recently when the latter studied Vittadini's type of *H. clathroides* and found it to be distinct. For the most part therefore the citations of specimens under the name *H. clathroides* in a previous publication (Ann. Missouri Bot. Gard. **16**: 95–96. 1929) apply to *H. separabile.* Since 1929 many collections of this species have been received from various localities and many have been found in Oregon but space will not be given to their citation here. The following large collection of both dried and preserved material is designated as the type of *H. separabile:* Oregon, Linn county, Trout Creek Forest Camp Recreational Area, May 21, 1938, *S. M. Zeller,* No. *8479,* type.

The peridium of this now historical species is almost entirely parenchyma. There is, however, a very thin layer of very fine, hyaline hyphae lining the inside of the parenchyma. The outer surface of the parenchymatous layer oxidizes at a rather early stage, becoming brownish and the smaller cells in this region may be found collapsed and may easily be mistaken for hyphae. The character of the surface is one distinguishing feature separating it from *H. affine.*

10. HYSTERANGIUM SETCHELLII Fischer, Ber. Schweiz. Bot. Ges. **48**: 33. 1938.

Fructifications subglobose, 0.5–1.5 cm. in diam., from abundantly branched, white mycelium; surface finely scurfy, brownish in preservative; peridium easily separable, 110–180 μ thick, of very compact, large gelatinous hyphae, the very thin splitting layer next to the gleba of much finer texture; gleba cartilaginous, dull slaty color, with broad milk-white septa, which radiate, scarcely branching from the center of the fructification to the peridium, and form an interrupted, more or less thick tramal peridium; columella prominent, white, reaching ½ to ⅔ to summit of fructification, scarcely branched except for the large septa (above); cavities relatively small, elongate, narrow, radiating; spores brownish-olive, fusiform, 14–19 × 5–6 μ.

[2] See reference to Fischer under *H. crassum.*

In duff under *Quercus densifolia*, Sunset Park, Santa Clara county, California, May 17, 1903, *N. L. Gardner*, No. *146*, type (in Univ. of Calif. Herb.).

The type of this species was loaned to the writer through the kindness of Dr. Lee Bonar. An amended description is presented above. The peridium of *H. Setchellii*, although evidently of a fundamental (primary) filamentous type, is so compact it might easily be construed by some as prosenchyma. The hyphae, however, are so parallel that the peridium is essentially filamentous.

In *H. Setchellii* and *H. crassirhachis* we have another pair of species illustrating the extreme parallelism between the two distinct groups of species in the genus *Hysterangium*. Our late colleague, Dr. Ed. Fischer, pointed out in his discussion of *H. Setchellii* the primitive nature of the species, a possible transition form from *Gautieria*, but on the other hand also its similarity to *H. crassirhachis*, a representative of that group of species having a pseudoparenchymatous or hymenial peridium. Several distinct pairs of species illustrate the strict parallelism between these two groups of species. For instance, to mention those with primary peridium first in each case, there are *Hysterangium Darkeri* Zeller and *H. Phillipsii* Harkness, *H. Fischeri* Zeller & Dodge and *H. affine* Massee & Rodw., *H. cistophilum* (Tul.) Zeller & Dodge and *H. separabile* Zeller, and *H. Setchellii* Fischer and *H. crassirhachis* Zeller & Dodge. If the one group is to be considered more primitive than the other it would seem necessary also to consider that the pairing species in the parallel line having hymenial peridium did not lag far behind the original line of development in the genus. In this connection it should be stated that there are many intermediate species in which the primary peridium persists along with the hymenial peridium.

If Fischer's contention is correct and a so-called hymenial peridium of parenchyma indicates a higher developmental stage in the phylogeny among the species of the genus *Hysterangium*, should one not look for a predominance of such structures in so-called higher families such as *Protophallaceae* and *Clathraceae* on the one hand and *Gelopellaceae* and *Phallaceae* on the other? This is not the case, however; the peridial structure in most of the genera of these families is primary.

It might perhaps be more logical to consider that there may be several lines of development within the genus *Hysterangium*, and that species having a spore magnitude similar to genera above and below may be considered within the most direct line of development. Such a concept would place *Hysterangium Darkeri* in the key position among the species of the genus with *H. Phillipsii* having closest affinities as to spore size and characters. The direct line would therefore be from *Protogaster* through *Rhizopogon* to *Hysterangium Darkeri*, thence to the *Protophallaceae* and *Clathraceae*. There must be some unknown steps between *Hysterangium Darkeri* and the *Gelopellaceae*, but the final connection seems logical.

11. **Leucogaster levisporus** sp. nov.

Fructificationes circa 2.5 cm. crassae, globosae vel irregulares, creteo-albae, griseol escentes; funiculis non raris; peridio 100–120 μ, siccitate 25–50 μ crasso, e parenchymate.e cellulis hyalinis, polyedricis, composito; gleba alba, locellis maturis a sparis farctis; septis prosenchymatibus, circa 30–45 μ crassis; basidiis clavatis, longis, superne 6–7 μ crassis, 4-sporigeris, sterigmatibus usque ad 22.5 μ longis, 2.5 μ latis; sporis hyalinis, sphericis vel ellipsoideis, 10–12.5 μ crass., levibus, episporo 1.2–1.5 μ crasso, utriculoque gelatinoso, 0.6–0.75 μ crasso vestitis; conidiis levibus, hyalinis, ellipsoideis, ceterum ut basidiosporis.

Fructifications up to 2.5 cm. in diameter, globose to irregular, chalk or milky-white becoming grayish; fibrils rather abundant; peridium 100–120 μ thick, drying 25–50 μ, composed of hyaline thin-walled parenchyma of polygonal cells which collapse on drying; gleba white, lacunae filled with spores at maturity; septa prosenchymatous, about 30–45 μ thick; hymenium of long-pedicelled basidia and conidiophores; basidia clavate of various lengths, 6–7 μ broad above, 4-spored; sterigmata of various lengths, up to 22.5 × 2.5 μ; spores hyaline, spherical to ellipsoid, 10–12.5 μ, smooth with an epispore 1.2–1.5 μ thick, covered by a gelatinous sheath about half as thick; conidia on long simple conidiophores, smooth, hyaline, and epispore as in basidiospores, ellipsoid.

In coniferous forest duff, Hat Point, 23 miles above Imnaha, Wallowa county, Oregon, *A. M. Rogers*, July 26, 1939, type.

Leucogaster levisporus is distinguished by the smooth spores and parenchymatous peridium.

12. **Leucogaster magnatus** (Harkness) comb. nov.
(Syn. *Leucophlebs magnata* Harkness.)

Fructifications up to 3 cm. in diameter, subglobose or elongate, white to ochraceous, smooth: peridium 120–150 μ thick, composed of fine, thick-walled, closely woven hyphae, white; gleba white, the freshly cut surface often showing a blue tint which soon vanishes, cavities decreasing in size toward the surface, sometimes full of cobwebby hyphae like a capillitium, often filled with spores; septa thin, homogeneous, 60–80 μ thick, composed of closely woven, hyaline hyphae; chlamydospores borne terminally on long slender branches of the cavity hyphae, hyaline, spherical, with very fine beaded echinulae, enclosed in a gelatinous sheath, 13 μ in diam.; basidia pyriform at tip, various lengths, 2- and 4-spored; basidiospores same in appearance as chlamydospores; peculiar odor.

Under conifers and broad-leaved trees. Western Oregon and California.

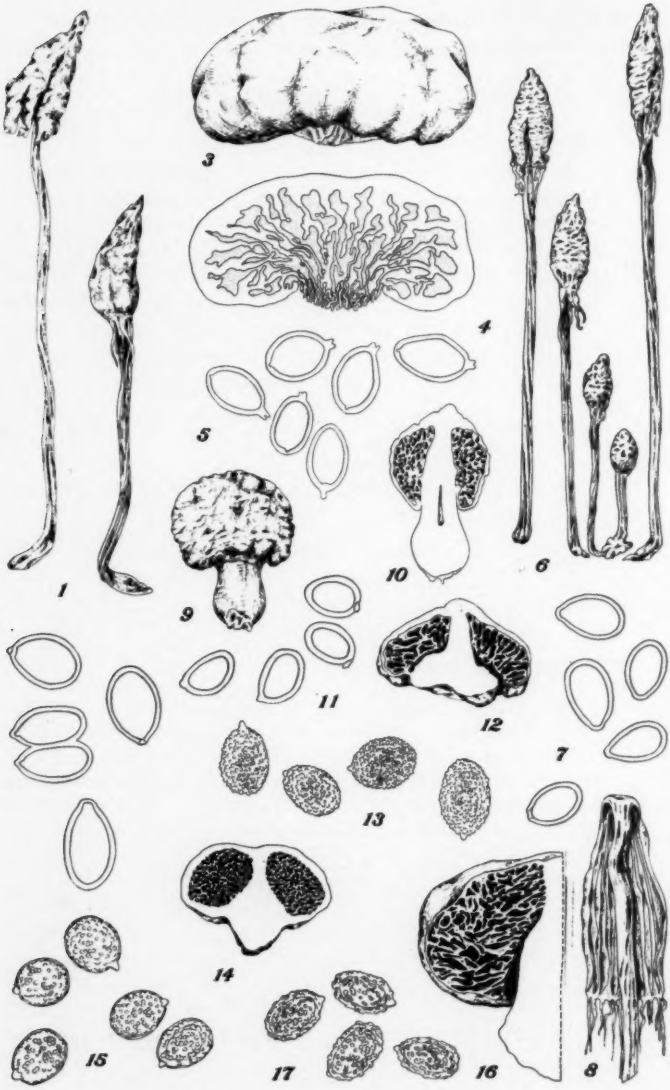
Specimens examined in addition to those previously reported:
Oregon: Benton county, Alsea Mt., Dec. 10, 1938, *Dr.* and *Mrs. D. P. Rogers* (in Zeller Herb. *8511, 8513*); 6 miles SW of Philomath, Nov. 11, 1939, *Max Doty.*
California: *H. E. Parks,* No. *37b* (sent in as *L. citrinus*).

13. **Secotium eburneum** sp. nov.

Fructificationes 1–1.5 cm. altae, 2.5 cm. crassae; pileo crasso-turbinato, 2.5 cm. crasso, 1–1.2 cm. alto; superficie laevi glutinosa, eburnea; stipite conico, inferne crasso superne in columellam crassam percurrentem procurrenti, solido, albo; peridio superne circa 1 mm. crasso, inferne tenuo e stipite separabili; gleba gilva, locellis parvis, e columella leviter radiantibus; sporis fusco-brunneis, leviter verrucosis, ellipsoideis vel ovoideis, 13–15 × 8.7–10 μ.

Fructifications 1–1.5 cm. tall, 2.5 cm. broad; cap broadly turbinate, 2.5 cm. broad, 1–1.2 cm. high (FIG. 12); surface smooth very slimy, viscid, pure glistening white; stipe hardly exceeding the cap below, conical, percurrent with broad bulbose base, solid, white throughout; peridium about 1 mm. thick above, thinner below; gleba gilvous, cavities small with a radiating tendency; basidia not seen; spores dark-brown, very slightly roughened, ellipsoid to ovoid, 13–15 × 8.7–10 μ (FIG. 13).

Under duff of White Pine, Monument Peak, Linn county, Oregon, *Helen M. Gilkey,* June 8, 1940, type.



FIGS. 1–17

14. **Secotium longipes** sp. nov.

Fructificationes 11–14 cm. altae, aliquantulum tenuibus; pileo 3–4 cm. longo, ad basim 1–2 cm. crasso, oblongo-ellipsoideo vel acute conico, apice acuminato, basi truncata, fibrillis longis decurrentibus ornata, superficie glabra, inferne in longitudinem striata vel subrimosa, pallide lutea, siccitate pallida vel obscure brunnes; stipite 2–2.5 mm. crasso, tereti, aequo cavo vel farcto, tenaci, glabro vel substriato, inferne subfibrilloso, concolori, ad basim fuscescenti; gleba fusco-brunnea, locellis magnis, elongatibus perumque e stipite radiantibus; cystidiis magnis, oblongis; sporis fuscis, laevibus, ovoideis vel ellipsoideis, episporo crasso, 11–14 × 6–8.5 μ.

Fructifications, 11–14 cm. tall, rather slender (FIG. 1); pileus 3–4 cm. long, 1–2 cm. broad at the base, oblong-ellipsoid to narrowly conical, apex sharply acuminate, base truncate with long decurrent fibrils which are lighter than the pileus, surface smooth, appearing somewhat longitudinally striate below, becoming somewhat rimose, yellowish-buff, drying lighter or dark-brown where bruised; stem 8–10 cm. long below pileus, 2–2.5 mm. diameter, terete, equal, hollow or stuffed, tough, smooth to slightly striate, slightly fibrillose below, concolorous, darker at the foot; gleba raw umber, coarsely cellular, cells elongate separated by thin anastomosing lamellar partitions; cystidia large, oblong; spores dark brown, smooth, ovoid to ellipsoid with thick epispore, with germ-pore at distal end, sometimes conjugating laterally, 11–14 × 6–8.5 μ (FIG. 2).

Scattered, on soil in marshy alpine meadow along creek, under *Ceanothus velutinus* and *Prunus emarginatus,* elevation 5700 ft., on south slope of Mt. Shasta, Siskiyou Co., California. July. Collected by *Wm. B. Cooke,* Nos. *10211, 10259, 13320,* type.

Mr. Cooke's notes on the habitat of *Secotium longipes* are as follows:

"In the transition zone where it merges with the Canadian zone

FIGS. 1–17. Drawings by Mrs. D. P. Rogers. 1, *Secotium longipes,* nat. size; 2, spores of *S. longipes,* × 1000; 3, *Sedecula pulvinata,* nat. size; 4, vertical median section of *S. pulvinata,* nat. size; 5, spores of *S. pulvinata,* × 500; 6, *Secotium polytrichoides,* × 1.5; 7, spores of *S. polytrichoides,* × 1000; 8, pileus of *S. polytrichoides* with one side cut away showing the lamellation of the gleba, × 4; 9, *Secotium nubigenum,* nat. size; 10, vertical median section of *S. nubigenum,* nat. size; 11, spores of *S. nubigenum,* × 1000; 12, vertical median section of *S. eburneum,* nat. size; 13, spores of *S. eburneum,* × 1000; 14, vertical median section of *Dendrogaster clasmomycetoides,* nat. size; 15, spores of *D. clasmomycetoides,* × 1000; 16, vertical median section of *Secotium pingue,* nat. size; 17, spores of *S. pingue,* × 1000.

on the south slope of Mt. Shasta is a large Veratrum meadow known as Wagon Camp. The west end of Wagon Camp is formed through the origin of a rather large spring. This spring flows to the junction with the west fork of Panther Creek until mid summer when it dries back toward its source. The area from which these specimens were taken includes a small flat marshy 'alluvial bottoms' type of location along the permanent portion of this creek. This bottoms section is about 5 ft. wide at the point where the specimens were collected. The forest is mainly *Abies magnifica* var. *shastensis* and *A. concolor*. *Ceanothus velutinus* and *Prunus emarginatus* form the understory at this point. Herbage along the creek includes species of *Mimulus, Epilobium, Salvia,* and various grasses. Fructifications of the fungus were scattered. At maturity the pileus droops to the ground making the older fruiting bodies rather inconspicuous."

15. SECOTIUM LUTESCENS Lloyd.

A study of the type material loaned by John A. Stevenson, Mycological Collections, Bureau of Plant Industry, USDA., revealed that this is not a *Secotium,* but rather an Agaric. It is most probably some species of *Galera.*

The spores are ellipsoid to ovoid, germ pore at distal end, attached obliquely below, brown, 11.2–13.2 × 6.2–7.6 μ.

16. SECOTIUM NUBIGENUM Harkness.

Through certain "acts of God" in California the type of this species has evidently been destroyed, there being no specimen under that name in the Harkness collections at the California Academy of Science or at the Dudley Herbarium, Stanford University. The Harkness species is so distinct in spore size and other characters, however, that material collected on Mt. Shasta by Wm. B. Cooke (No. *10174*) was readily referred to it. The specimens were growing on rotten logs of *Abies magnifica* var. *shastensis,* July 1, 1938.

The formal description of *S. nubigenum* is as follows:

Fructifications gregarious or solitary, subglobose to turbinate, subpileate and umbonate, base more or less conical and covered

by a scanty, evanescent veil, 1.5–4 cm. broad, 2–4 cm. tall (FIGS. 9, 10); surface grayish straw-colored to darker, smooth; peridium thin, sometimes breaking away from the stipe below; gleba brown, with variable sized cavities; stipe stout, somewhat bulbose, tapering upward, percurrent above; a few ovoid cystidia present; spores ellipsoid to ovoid, brown, smooth, 6.5–8.2 × 4.9–5.4 μ (FIG. 11).

17. **Secotium pingue** sp. nov.

Fructificationes 5–6 cm. altae, 5 cm. crassae; pileo depresso-globoso, firmo, ad basim penitus excavato, superficie laevi, luteo-albida cum maculis brunneo-lutescentibus; stipite concolori, glabro, sursum attenuato, inferne ultra 2 cm. crasso, superne in columellam crassam percurrentem procurrenti, farcto; peridio superne circa 2 mm. crasso, inferne tenuissimo e stipite separabili; gleba fusco-brunnea, locellis parvis, e columella radiantibus; basidiis anguste clavatis, 2- et 4-sporigeris; sporis fusco-brunneis, ovoideo-ellipsoideis, verrucosis, 12.5–16.3 × 8–9.5 μ.

Fructifications 5–6 cm. tall, 5 cm. broad; cap depressed globose, base excavated ⅓ the way up the columella, firm (FIG. 16); surface smooth, buffy whitish with brownish-yellow spots in preservative; stipe concolorous smooth, tapering upward, over 2 cm. in diameter below, percurrent as a stout columella, stuffed; peridium about 2 mm. thick above, very thin below where it separates from the stipe; gleba Dresden brown in preservative; cavities small, radiating from the columella; basidia narrowly clavate, 2- and 4-spored; spores dark brown, ovoid-ellipsoid, verrucose, 12.5–16.3 × 8–9.5 μ (FIG. 17).

Under duff on *Abies*, grove south of Horse Camp, Mt. Shasta, California, July 25, 1939, *Wm. B. Cooke*, No. *13362*, type (in Zeller Herb.).

Under oil immersion the spores are distinctly verrucose, especially so at and near the distal end. In lactophenol-fuchsin-methol-blue the spores show a closely applied gelatinous sheath (utricle). Many spores have a very short papillate remains of the sterigma. Sought out by rodents.

18. **Secotium polytrichoides** sp. nov.

Fructificationes 3.5–11 cm. altae, tenuissimae; pileo 6–12 mm. alto, ad basim 3–4 mm. crasso, ellipsoideo vel conico, apice acuto, basi attenuata vel truncata, margine fibrillis albis longis decurrentibus fimbriato, superficie glabra, inferne subrimosa, cremea, siccitate obscuriore; stipite 1–2 mm. crasso, terete, aequo, tenaci, glabro, concolori; gleba fusco-brunnea, locellis

paucis, elongatis, plerumque e stipite radiantibus; sporis fusco-brunneis, laevibus, obovoideis, episporo crasso, 8.7–10 × 5.8–6.3 μ.

Fructifications 3.5–11 cm. tall, very slender (FIG. 6); pileus 6–12 mm. long, 3–4 mm. broad at the base, ellipsoid or conical, apex acute, base attenuate or truncate at maturity, margin fimbriate, mostly with long decurrent, whitish fibrils, surface smooth, somewhat rimose below, tan, drying darker; stem 3–9 cm. long below the pileus, 1–2 mm. in diameter, terete, equal, tough, smooth, concolorous; gleba dark-brown, cavities few, elongate, separated by thin anastomosing lamellar partitions (FIG. 8); spores dark-brown, smooth, obovoid with a thick epispore, 8.7–10 × 5.8–6.3 μ (FIG. 7).

Scatteringly gregarious, on moist ground among grass and rushes, elevation 8100 ft., Horse Camp, Mt. Shasta, Siskiyou county, California. July and August. Collected by *Wm. B. Cooke*, Nos. *7646* (in Univ. of Calif. Herb. No. *568640*), *8612, 8623, 8660, 10276 type, 13313.*

The small nodding caps on very slender wire-like stems remind one of the stalked fruiting capsules of the moss, *Polytrichum*, with calyptra closely hugging the capsule and stem; some of them are not much larger.

Sedecula gen. nov.

Fructificationes hypogeae, pulvinatae, coriaceae, sine basi sterili radicibusque; peridio crasso, superne coriaceo, inferne paene obsoleto dehiscentique; gleba atra, pulveracenti, cum venis crassis albis, a peridio in centrum vergentibus, ceterum ut *Sclerodermatis;* sporis brunneis, ellipsoideis vel irregularibus, laevibus.

Fructifications hypogeous, pulvinate, leathery, without sterile base or radicle; peridium thick, leathery above, almost obsolete below, dehiscing below; gleba black with broad whitish veins extending inward from the peridium, becoming powdery and otherwise as in *Scleroderma;* spores brown, ellipsoid to irregular, smooth.

Type species, *Sedecula pulvinata.*

This odd genus because of its heavy peridium and glebal characters is referred to the *Sclerodermataceae.* Young specimens should be studied to learn the sequence of glebal development. From the 3 mature specimens at hand development of the gleba would appear to be centripetal.

19. **Sedecula pulvinata** sp. nov.

Fructificationes pulvinatae, 2–6 cm. crassae, 1–3 cm. altae, superficie glabra vel granulosa, alba vel griseola; peridio tenaci, coriaceo, superne 2–3 mm. crasso, inferne tenui subevanescentique, peridii crassi marginibus leviter involutis, parenchymaticis, albidis, cellulis magnis compositis; glebae parietibus magnis in centrum a peridiis vergentibus; gleba atra, pulverascenti; basidiis clavatis, 2-sporigeris, sterigmatibus brevibus; sporis obscure brunneis, ovoideis vel subellipsoideis vel irregularibus, breve pedicellatis, 23–26 × 13–16.2 μ.

Fructifications pulvinate, 2–6 cm. broad, 1–3 cm. high, surface smooth to granular, white to grayish (FIGS. 3, 4); peridium tough, leathery, 2–3 mm. thick above, thin and almost evanescent below, margin of thicker peridium usually somewhat rolled under so as sometimes to elevate the basal or under side having the thinner peridial cover, composed of whitish parenchyma of large cells with heavy gelatinized walls; larger partitions of the gleba (plates) extend centripetally to unequal depths toward the base and center from the peridium with which they have unbroken connection and the same structure; gleba black except for the whitish partitions (plates), becoming powdery at maturity; basidia narrrow-clavate, 2-spored; sterigmata about as long as the spores, slender; spores dark-brown (black in mass), ovoid to somewhat ellipsoid or irregular, usually very short-pedicellate, 23–26 × 13–16.2 μ (FIG. 5).

Under Shasta Fir duff, elevation 7000 feet on Mt. Shasta, Siskiyou county, California, *W. B. Cooke,* No. *10,307,* type, Sept. 16, 1938. (In Cooke Herb. and in Zeller Herb. No. *8497.*)

20. ABSTOMA RETICULATUM Cunningham.

Under Cypress, Point Lobos near Pacific Grove, Monterey county, Calif. Two collections were taken by Dr. Gertrude S. Burlingham, Jan. 6 and Mar. 26, 1937.

It is of interest to give this first report of a species of *Abstoma* from America, the genus having been reported before from Australia and New Zealand only. Dr. G. H. Cunningham, author of the genus, says in verification of our identification of one of the California collections, "I should refer it with confidence to *A. reticulatum.*"

21. CALVATIA TATRENSIS Hollos.

Hat Point about 23 miles above Imnaha, Wallowa county, Oregon; collected by Dr. D. P. Rogers, July 27, 1939.

This is the first report of this fungus from America but it answers the description by Hollos perfectly, and occurs at altitudes in Oregon mountains similar to those reported by Hollos in central Europe.

22. **Endogone rosea** sp. nov.

Fructificationes spheroideae vel pyriformibus, basi sterili inferne attenuata, cum funiculo tenui, 3–9 mm. crassae; superficie levi, alba, griseolescenti; intus zygosporiferae roseae, firmae; zygosporis in parte superiore dissipatis e conjugatione hypharum magnarum duarum ortis, 110–125 × 60–90 μ.

Fructifications spheroid to pyriform, attached below by a sterile base, 3–9 mm. in diam.; surface smooth, white, becoming grayish; zygosporiferous interior a rosy-color, firm; zygospores arising scatteringly throughout the upper portion, from the conjugation of two large swollen hyphae from which cells are cut by subtending septa, 110–125 × 60–90 μ.

About one inch under forest duff. Collected by *H. M. Gilkey*, foot of Alsea Mt., Benton Co., Oregon.

THE TAXONOMY OF ZENKER'S LEPTOSTROMA CAMELLIAE

WILLIAM W. DIEHL

(WITH 1 FIGURE)

Over a century ago Zenker[1] published a short account of a newly discovered fungus found upon leaves of *Camellia japonica*. He did not explain where the fungus and its host were found; but it is a natural assumption that it was in Germany, either at Jena where he lived or nearby, since by that time *Camellia* culture had ceased to be a novelty. It is, moreover, most unlikely that the specimen was found distant from that locality or the record would be explicit. Although the species would seem to be morphologically distinctive and it was duly recorded in the Sylloge Fungorum of Saccardo, there appears to have been no other record of it despite the fact that it might have been expected to appear again upon Camellias.

AN AMERICAN RECORD

That Zenker's description and illustrations (FIG. *A*) are trustworthy is, however, borne out by the evidence of some specimens sent from the A. & M. College of Mississippi in November 1931 and also from Meridian, Miss. (FIG. *B*), in December 1931.[2] The writer identified these specimens and was naturally impressed by the startling reappearance of Zenker's species after the lapse of nearly a century. It seemed, therefore, worth while to attempt an explanation for this reappearance and to obtain, if possible, more complete information on the life history of the fungus since there was a possibility that it might be a pathogen newly arrived in

[1] Zenker, J. C. Ueber einen neuen Pilz auf *Camellia japonica*. Flora 17[1]: 211–213. *pl. III, fig. 1–7*. 1834.

[2] These specimens were collected by Clay Lyle and M. L. Grimes, respectively; Mr. Lyle's specimen was most kindly made available by Miss V. K. Charles.

America. The fungus was, consequently, given more thorough study than would be accorded the usual problem in specific identification, including cultivating it upon artificial media and searching for it in the field.

APPEARANCE OF THE SPECIMENS

The specimens were small, black, button-like pads about 2 mm. in diameter, firmly attached or agglutinated to the surface of the green *Camellia* leaf, with every indication of having grown there either out of the leaf or from some insect upon it. There was no discoloration of the leaves and a study of stained sections of the leaf tissues with the attached fungous pads made free-hand and of imbedded material cut with the microtome,[3] failed to disclose any hyphae within the leaf tissues. There was likewise no sign of insect remains upon which the fungus might have subsisted.

CULTURES ON ARTIFICIAL MEDIA

Pure cultures were easily obtained upon cornmeal agar, and transfers to several of the common agar media grew readily to form a gray cottony growth that in tubes with waxed stoppers did not form any fructifications during the entire year they were kept under observation. The only diagnostic feature noted was clamp-connection hyphae which suggested that the fungus was a Basidiomycete.

FIELD OBSERVATIONS

Late in December 1932 on a motor trip from Washington, D. C., to South Florida, considerable time was spent at likely places on the way in looking for this fungus upon the leaves of *Camellia* bushes. On the return, however, at Savannah, Ga. (Jan. 6, 1933) a stop was made at a commercial nursery to examine a large collection of *Camellia* plants where the answer to the problem appeared made to order:

Numerous large bushes were growing luxuriantly in the protection of a lath-shade. The lower leaves on many bushes were

[3] The writer is indebted to Dr. R. M. Whelden, of Cambridge, Mass., for the preparation of these microtome sections.

liberally speckled, chiefly on the under surfaces, with black, button-shaped fungous pads similar to those on the specimens from Mississippi. In the Georgia material, the "buttons" were, however, of smaller diameter—possibly a different but related species! It was noted that the "buttons" were especially common on leaves near the ground becoming scarcer above two feet high. As in the Mississippi specimens there was here no discoloration of the leaves where these "buttons" were attached. Leaves were searched for evidence of scale or other possible insect host upon which the fungus might have grown, but the foliage was exceptionally clean and free from any suggestive insect host. It was reasoned that, since most of these black fungous "buttons" were on the lower sides of the leaves, more rarely on top, chiefly near the ground, they might have been projected from some point of origin below. On the ground in the deep shade of these evergreen bushes was a checker-board pattern of wood slivers, decaying fragments of the boxes which had originally contained the rooted *Camellia* cuttings now become large bushes. As the roots had grown through the rotted bottoms of these boxes into the soil below, all the boxes had disintegrated except for the upper parts of the sides now left as slivers. These decayed remnants of the boxes were liberally studded with the funnel-shaped fruits of a bird's-nest fungus, which was later identified as *Cyathus pallidus* Berk. & Curt.; and the eggs or peridioles of this fungus were identical with the black, button-like pads upon the foliage above. With this comparable case in evidence it is a relatively simple matter to identify the glutinous, black, button-like fungous pads on the *Camellia* leaves from Mississippi (FIG. *B*) as peridioles belonging to some species of *Cyathus*.

THE SYNONYMY OF LEPTOSTROMA CAMELLIAE

Zenker's fungus might, of course, be referred to other genera were it not for the presence of remnants of a well developed funiculus actually indicated by the apical papilla in Zenker's illustrations here reproduced (FIG. *A*: 3–6) as well as shown in the illustration of the section of a Mississippi specimen where it is under the attached periodiole (FIG. *C*). In certain of the Mis-

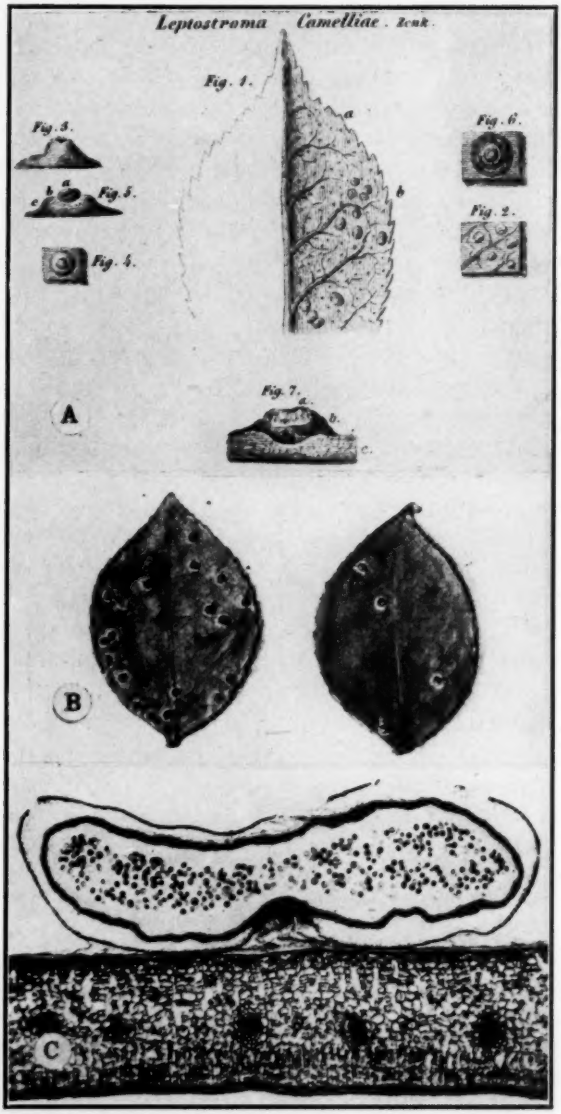

Leptostroma Camelliae. Zenk.
Fig. 1.
Fig. 3.
Fig. 5.
Fig. 4.
Fig. 6.
Fig. 2.
Fig. 7.
A
B
C

FIG. 1.

sissippi material the funiculus was coiled up, appearing as an apical papilla oriented in reverse with relation to the *Camellia* leaf as in Zenker's illustration. The spores are similar in size and shape to those of *Cyathus stercoreus* (Schw.) De-Toni, which was not known to occur in Europe in 1834, although it is now recognized as practically cosmopolitan. It is ubiquitous on dung and manured substrata and is a species most likely to have been growing upon the ground or upon wooden receptacles in which Zenker's *Camellia* bushes were grown. The extremely glutinous surface of wetted peridioles of this species causes them to adhere closely to any substratum.

No attempt is made at this time to explain how peridioles could be projected through the air to leaves above the sporocarps of this species, but G. W. Martin's account [4] of the dissemination by spattering raindrops of peridioles in the related *Crucibulum vulgare* is very suggestive.

CONCLUSION

Leptostroma Camelliae Zenker, hitherto unknown except for the original description of a fungus on *Camellia* leaves, is here identified as peridioles of *Cyathus stercoreus* (Schw.) De-Toni. The peridioles of this species as well as of the related *C. pallidus* Berk. & Curt. when projected onto leaves and other objects adhere so closely by means of a glutinous coating that they appear to have grown in that position.

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[4] Martin, G. W. Basidia and spores of the Nidulariaceae. Mycologia **19**: 234–247. 1927.

FIG. 1, *A*, reproduction of Zenker's illustration of *Leptostroma Camelliae* from Flora **17**: pl. III. 1834; *B*, photograph from watercolor drawing of two *Camellia* leaves from Meridian, Miss., 1931, showing attached peridioles of *Cyathus stercoreus* (× 0.6); *C*, photomicrograph of vertical section through peridiole of *Cyathus stercoreus* attached to *Camellia* leaf (× 400). (Photographs by M. L. F. Foubert.)

OBSERVATIONS ON CERTAIN SPECIES OF APHANOMYCES[1]

VICTOR M. CUTTER, JR.

(WITH 15 FIGURES)

While searching for Phycomycetous fungi in the submerged exuviae of aquatic insects during the summer of 1940, several interesting species of the genus *Aphanomyces* were encountered. The identity of two of these proved puzzling and a search of the existing literature on the subject indicated that neither of them corresponded completely with any published description. Since these forms appeared to be fairly common in the vicinity of Ann Arbor, Michigan, further study of them seemed desirable. At the same time, Dr. F. K. Sparrow, Jr., kindly made available preserved material of a number of other species of *Aphanomyces*, collected from time to time by him. A study of these forms revealed a great deal of variation among them. Since the preserved material was in excellent condition, it appeared worthwhile to undertake a comparative morphological study of as many of the aquatic species of this genus as possible in the hope of clarifying to some extent certain obscure aspects of these fungi, in particular, specific limits.

The genus *Aphanomyces* was erected by de Bary in 1860 and since that time approximately 20 more or less distinct species have been described by various workers from many parts of the world. It is interesting to note that the species are for the most part distributed in the temperate zones, and few records are extant from any tropical countries. Species have been described from many types of substrate, including other aquatic fungi, algae, the exuviae of aquatic insects, insect cadavers in water, aquatic animals, and higher plants.

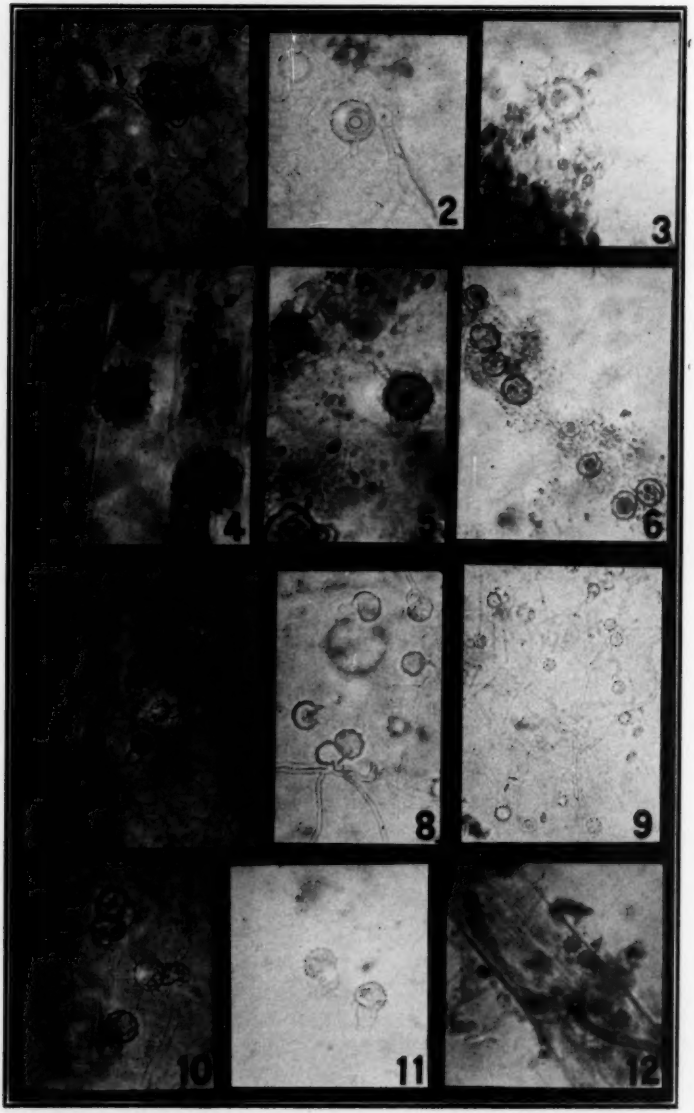
The members of this genus fall into two main categories de-

[1] Contribution from the Department of Botany, Univ. of Michigan No. 770.

pendent on the characteristics of the oögonial wall, which may be smooth or variously ornamented. Species with smooth oögonial walls, of which *A. laevis* de Bary may be considered typical, are for the most part saprophytes on various organic substrates or parasites of aquatic animals and higher plants. Drechsler (**5**) has described a series of smooth walled congeneric forms occurring in nature as parasites of various vegetables, all of which may be cultivated as saprophytes on artificial media, and hence are probably only facultative parasites. *A. laevis* de Bary, apparently the most commonly collected species of the genus, has been reported from a wide variety of substrates, usually from aquatic habitats. Coker (**2**), Couch (**3**), and Petersen (**9**) have pointed out that it is in all probability a very variable species. Bartsch and Wolf (**1**) have described a smooth walled species *A. acinetophagus* which attacks the protozoan *Acineta flava*. *A. helicoides* Minden, the remaining smooth walled species, has been reported on ant eggs in water. The other species of the genus are all characterized by the presence on the oögonial walls of roughenings, tuberculations, or spines. To judge from the infrequent reports in the literature these species are of sporadic occurrence, and as far as is now known are strictly aquatic. Couch (**3**) has pointed out that most of them upon occasion show parasitic tendencies. The only thoroughly investigated form in this series, *A. exoparasiticus* Coker & Couch, has been shown (**3**) to act under various conditions as a parasite, a hemi-parasite, or a true saprophyte.

Little is known concerning the degree of intergradation occurring among the several closely related species with ornamented oögonial walls. This is probably due in part to the difficulties involved in securing sufficient material for a comparative study, and in part to certain obvious discrepancies in the older literature which obscure our conceptions of specific limits. The results of the present study indicate, however, that the thickness of the oöspore wall is remarkably consistent in a given species and furnishes a most important and reliable supplementary character for the separation of species. This will be discussed under the species concerned.

Materials for this investigation were obtained from numerous collections of insects, exuviae, and algae in the vicinity of Ann



FIGS. 1–12.

Arbor, Michigan, and in preserved material of similar type collected by Sparrow from Denmark, England, Ithaca, N. Y., Cold Spring Harbor, N. Y., and Arlington, Mass. For the most part no attempts were made to grow these forms in pure culture, and all observations were made from material *in situ*. However, *A. laevis* and *A. helicoides* were both grown in water culture for a short period of time on the boiled cotyledons of Indian Hemp. With one or two exceptions, cultures of the forms so grown remained in the vegetative condition and did not produce sex organs.

SPECIES OBSERVED

APHANOMYCES HELICOIDES Minden. Krypt.-fl. Brand. **5**: 556. 1915. FIGS. 1, 2, 13 G–L.

The type material of this species was collected near Hamburg, Germany, on ant eggs in water. So far as is known, it has not since been reported. Coker (**2**) points out that it may probably only represent an extreme variation of *A. laevis*, in which the oögonial wall exhibits a brownish coloration and the antheridial branches show a strong tendency to involve the oögonium and the oögonial stalk in an helical coil. He mentions in this connection a form of *A. laevis* collected at Chapel Hill, N. C., in which the same pronounced coiling on the part of the antheridial branches was observed. However, Minden's fungus is further characterized by the tendency of the oögonia to occur in dense groups, and by the presence of certain antheridial tangles which form indiscriminately on the mycelia even where oögonia are lacking. Couch (**3**) describes a form of *A. laevis* from Wisconsin which in almost all respects fits Minden's description. To judge from Couch's remarks, however, the helical nature of the antheridial branches in his form is not so pronounced as in *A. helicoides*.

FIG. 1. *A. helicoides*. Showing helical nature of branches. Arrow indicates oögonial stalk. × 400. FIG. 2. *A. helicoides*. Oögonia with thin walled oöspore. × 400. FIG. 3. *A. Sparrowi*. On *Nitella* sp. Oögonia growing among host chloroplasts. Note bifurcated spines. × 600. FIGS. 4–5. *A. phycophilus*. On *Spirogyra* sp. Oögonia at lower right of fig. 4 growing inside host cell. × 400. FIG. 6. *A. scaber*. In filament of *Spirogyra* sp. × 400. FIGS. 7–11. *A. amphigynus*. On exuvia of a mayfly. × 600. Fig. 9 ×280. FIG. 12. *A. parasiticus*. On hyphal thread of *Achlya* sp.

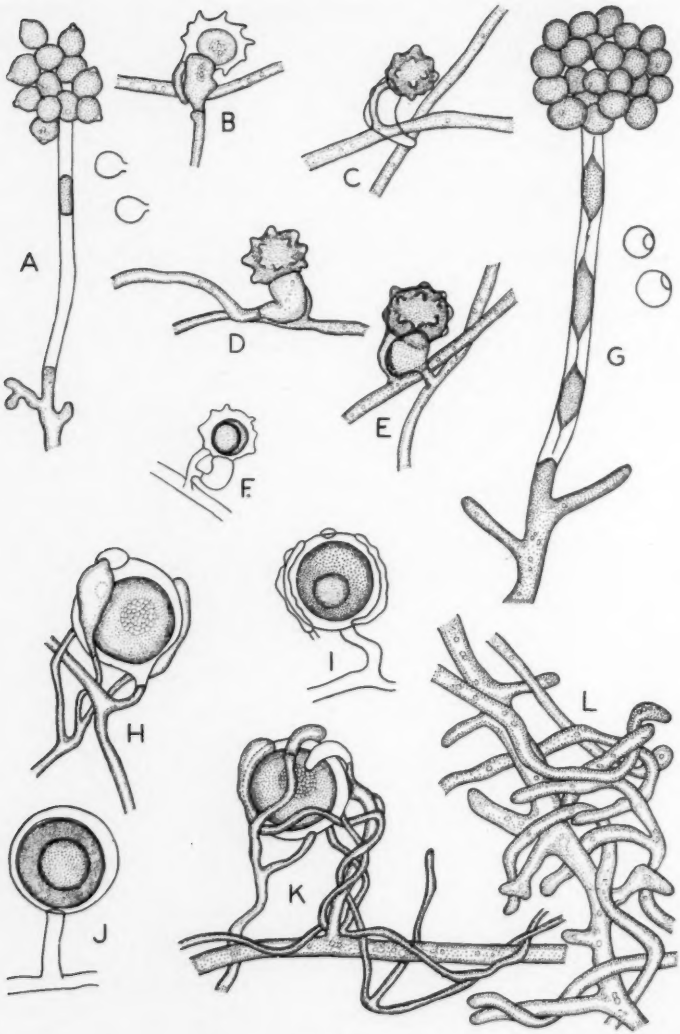


FIG. 13.

In the vicinity of Ann Arbor, Michigan, a fungus is commonly found in the submerged exuviae of certain aquatic insects, particularly those of the larger *Ephemerida* and *Odonata*, which in all respects corresponds closely with Minden's description of *A. helicoides*. In certain localities almost every one of these exuviae examined was found to harbor it. The oögonia are produced abundantly in characteristically scattered groups, as many as 30 or 40 sometimes occurring together in one group. This grouping of the oogonia suggests the possibility of a heterothallic condition, although further investigation will be required to verify this. The oögonial walls are at all times smooth and unpitted, but in age may because of the persistent nature of the collapsed antheridia appear somewhat roughened (FIG. 13, *I*). At many points on the vegetative mycelium clusters of short intertwined mycelial branches arise to form characteristic knots (FIG. 13, *L*), which in the author's opinion appear to correspond to the antheridial tangles mentioned by Minden (**8**). The function of these mycelial knots is uncertain, but they may possibly arise as the result of an incomplete sexual stimulus, or in response to an increased nutrient concentration in certain portions of the substrate. They are distinguished with difficulty from the functional antheridial branches but may be somewhat thicker and more convoluted. The number of antheridia associated with a single oögonium is very variable in this form but averages 3–5. The antheridial branches are commonly long and diclinous, and show a pronounced coiling or snake-like twisting around the oögonial stalk. This characteristic is maintained in material grown on hempseed in water culture, although the oögonia are scarce under these circumstances. The sporangia in this species are in no way distinguishable from those of *A. laevis*, but the vegetative mycelium from which they arise commonly displays a light brown color, which is not, however,

FIG. 13. All drawings made with the aid of a camera lucida at an approximate magnification of 600 diameters. *A*, *A. amphigynus*, zoösporangium showing strongly papillate cystospores and empty cysts; *B–F*, *A. amphigynus*, types of oögonia and antheridia; *G*, *A. helicoides*, zoösporangium with cystospores and empty cysts; *H–K*, *A. helicoides*, types of oögonia and antheridia; *I* shows a mature oögonium with walls apparently roughened due to persistent antheridia (note thin wall of mature oöspore in *J*); *L*, *A. helicoides*, characteristic hyphal knot that may correspond to the antheridial tangles referred to in text.

retained in material grown on hempseed. Our material is further characterized by the extremely thin wall of the mature oöspore (FIG. 13, *J*), which in all of the material examined never attained a thickness of more than 1.5 μ. Minden (**8**) unfortunately does not state the thickness of the oöspore wall in his species, but since our material corresponds so perfectly with his description in all other respects we feel justified in referring it to *A. helicoides*. The extremely thin nature of the oöspore wall serves to separate this material from *A. laevis*, which has been described by several investigators as having a thickened oöspore wall up to 3 μ in thickness, and from the form of *A. laevis* described by Couch (**3**) which has an oöspore wall that is conspicuously thickened. In apparently typical material of *A. laevis* studied during the course of this investigation the oöspore wall was commonly 2.5–3 μ thick. Although Coker (**2**) has pointed out that the limits of *A. laevis* may be extended to embrace *A. helicoides*, it appears on the basis of the characters mentioned above to be specifically distinct. The following description was compiled from the Michigan material.

Hyphae hyaline or brownish, 4–7.5 μ in diam., abundantly branched, sometimes forming characteristic knots, ramifying through and over the substrate; sporangia long, not to be distinguished from the vegetative mycelium, terminal or lateral; zoöspores in a single file in the sporangium, spindle-shaped with sharp tapering ends, $5 \times 10\ \mu$, becoming globose upon emergence and encysting at the mouth of sporangium, cystospores 8–11 μ in diam., free swimming zoöspores bean-shaped, laterally biflagellate, $6 \times 9\ \mu$; oögonia on short, lateral branches, frequently in dense clusters on the substrate, 21–35 μ in diam. with smooth, brownish, unpitted walls; oöspores single, large, oil globule eccentric at maturity, oöspore wall very thin, rarely reaching 1.5 μ in thickness; antheridia 1–5 μ, present on all oögonia, androgynous or diclinous, wrapping closely around the oögonium and sometimes almost covering it, persistent after fertilization, then appearing as roughenings on the oögonial walls; antheridial branches slender, frequently in helical coils around the oögonial stalks.

Saprophytic on the exuviae of aquatic insects. On hempseed forming a limited, scarcely branched, white mycelium 2–4 mm. in extent.

APHANOMYCES LAEVIS de Bary forma.

A form, which differed from typical *A. laevis* in the smaller dimensions of its oögonia and oöspores and in its more slender vegetative hyphae, was collected once on the nymph of a species of *Odonata*. It was particularly noteworthy because of the extremely short oögonial stalks and the peculiar diverticulate nature of the antheridial cluster. The branches that formed these clusters were very short and swollen, and arose close to the oögonia but on different branches. No instance could be found where the antheridia were definitely androgynous. Since this form was not obtained in culture, it does not seem worthy of specific designation without further study.

Hyphae hyaline, 3–6.5 μ in diam., abundantly branched; sporangia long, same diameter as vegetative hyphae; zoöspores as in the species, cystospores 7–9 μ in diam.; oögonia spherical with hyaline, unpitted, thin walls, on very short lateral branches, 15–21 μ in diam.; oöspores single, hyaline, 12–18 μ in diam. with eccentric oil globule, wall up to 2 μ thick; antheridia diclinous, much lobed and convoluted, 3–5 μ on most oögonia, the antheridial branches very short, forming a characteristic cluster around the oögonium, persistent after fertilization.

Saprophytic on the nymph of a species of Odonata, Whitmore Lake, Washtenaw County, Mich., June 18, 1940.

Aphanomyces amphigynus sp. nov.

This species was encountered quite frequently in the larval skins of various aquatic insects around Ann Arbor, Michigan. It was also frequent in preserved exuviae collected in 1933 in Sealand, Denmark, by Dr. F. K. Sparrow, Jr. A fungus collected on grass culms suspended in water at Slaterville Springs, N. Y., by Sparrow, and reported by him (**12**) as *A. exoparasiticus* Coker & Couch, also appears from an examination of slides to be referable to the present species.

In the American material the oögonia generally appeared after the exuviae had been kept in a culture jar in water in the laboratory for about ten days. In the collection on grass culms the oögonia were scarce. The mycelium of the fungus was quite limited in extent, rarely occupying more than a small portion of the larval skin.

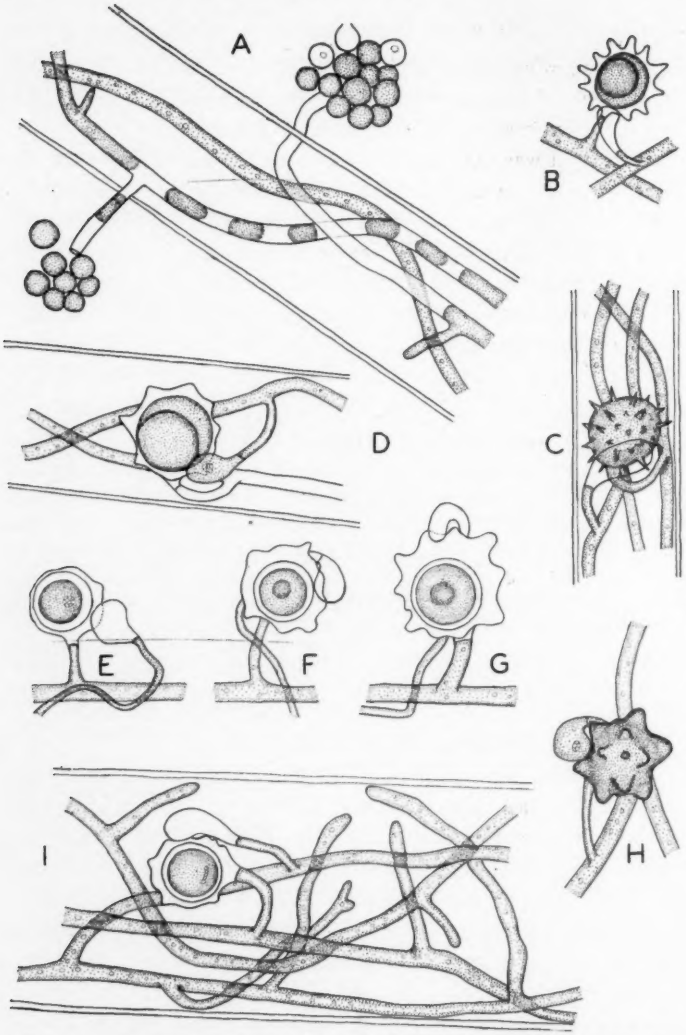


FIG. 14. All drawings made with the aid of a camera lucida, at an approximate magnification of 600 diameters. *A, A. parasiticus,* zoösporangia in hyphae of *Dictyuchus monosporus; B–B, A. parasiticus,* in hyphae of Achlya sp.; types of oögonia and antheridia (note large oöspore filling oögonium and prominent oil globule); *E–L, A. scaber,* on filaments of *Spirogyra* sp.; types of oögonia and antheridia (note subcentric nature of oil globule in *F* and *G*).

As may be seen from the accompanying description, *A. amphigynus* is evidently most closely related to *A. parasiticus* Coker, but differs in several very important respects. *A. parasiticus* has been reported only as an obligate parasite of certain other Saprolegniaceous fungi by Coker (**2**) and by Couch (**3**) and all efforts to culture it as a saprophyte have been unsuccessful. The present species on the other hand is obviously saprophytic. Well defined morphological differences are also apparent. The non-sexual stage of *A. amphigynus* may be distinguished from that of *A. parasiticus* by the strongly papillate nature of the cystospores. This character is pronounced not only at the time of emergence of the free swimming, laterally biflagellate zoöspores, but also throughout their period of encystment. The hyphal measurements are somewhat smaller than those of *A. parasiticus*. Further, Coker (**2**) has described the oögonial walls of his fungus as being warted to strongly spiny, and all the authentic material of *A. parasiticus* that has been examined by the author has had walls of the strongly spiny type. Sparrow (**11**) in discussing a fungus collected by him at Cold Spring Harbor, N. Y., on a species of *Achlya,* and designated as *A. parasiticus,* states that the dark-colored oögonial wall bore sharp, gradually attenuated spines 5–8 μ in length. His illustrations correspond well with those of Coker (**2**). In the present fungus the oögonial wall is characteristically more tuberculate than spiny, and the tubercles are but rarely sharp-pointed. The nature of the mature oöspore also appears to afford a reliable basis on which to distinguish these two species. In *A. parasiticus* the oöspore has been described as 12–21 μ in diameter, filling the oögonium completely at maturity. This description is verified in our material of *A. parasiticus*. In *A. amphigynus,* on the other hand, the oöspore is only 9–13 μ in diameter and in no instance does it even approximately fill the oögonium. Further, the antheridia of our species are somewhat larger in relation to the size of the oögonia than the antheridia figured by Coker (**2**) for *A. parasiticus*. Indeed, in many cases the single basal antheridium is larger than the oögonium (FIGS. 8, 10), and at times a single antheridium appears to fertilize two oögonia. Finally, measurements compiled from a large amount of Danish and American

material show our fungus to be somewhat smaller than *A. parasiticus*. For these reasons, it appears worthy of specific designation. The name proposed refers to the peculiar nature of the antheridia which frequently give the appearance of being penetrated by the oögonial stalk.

Hyphae hyaline, 2.5–4 μ in diam., sparingly branched, restricted, running over the surface of and through the substrate; sporangia short, of same diameter as the vegetative hyphae, terminal; zoöspores oblong with blunt rounded ends, formed in a single row in the sporangium, upon emergence becoming globose and encysting, cystospores 8–12 in number, 5–7 μ in diam. with a prominent papilla, free swimming zoöspores reniform, laterally biflagellate, 3 × 6 μ; oögonia 12–16 μ in diam. exclusive of the spines, borne on short circinate stalks, the oögonial wall hyaline, bearing scattered spines or blunt tubercles which may reach 2.5 μ in length; oöspores single, eccentric, not filling the oögonium, 9–13 μ in diam.; antheridia diclinous, single, large, bulbous, broad clavate, or irregularly oval, 9 × 14 μ, always applied basally and persistent after fertilization, at times appearing amphigynous to the oögonial stalk.

Hyphae hyalinae 2.5–4 μ crassae, parce ramosae, terminatae, percurrentes et summa substratum; sporangia brevia, terminalia, 2.5–4 μ diam.; zoosporae oblongae cum obtusis rotundis extremis, formati in una serie in sporangia, cum emergunt globosae encystantes, cystis 8–12 num., 5–7 μ diam. cum papilla prominente, zoosporae natantes reniformae, lateraliter biflagellatae 3 × 6 μ; oogonia 12–16 μ diam., sine spinis, prolata brevibus circinnatus stirpibus, murus oogoniarum hyalinus, ferens paucas acutas spinas vel obtusis processus usque 2.5 μ long.; oosporae singulae, eccentricae, non complentes oogonia, 9–13 μ diam.; antheridia declinus, solitaria, magna, tumefacta, lata clavata vel irregulariter ovata, 9 × 14 μ, semper applicata funditus et constantia post evacuaverunt, aliquando verisimilis amphigynia stirpi oogoniae.

Saprophytic on exuviae of aquatic insects. Type locality: Esröm Sö, Sealand, Denmark. Coll. F. K. Sparrow, Jr., 1933. Also in North America.

APHANOMYCES PARASITICUS Coker. The Saprolegniaceae; Chapel Hill, 165–167. *Pl. 57.* 1923.

Material of this species has been examined in collections made at Bartlett Pond, Arlington, Mass., 1928 and at Barton Mills, Suffolk, England, 1932 by Sparrow. The English fungus was

parasitizing *Dictyuchus monosporus* Lietgeb, whereas the American material occurred on an unidentified species of *Achlya*. All of the oögonia observed were of the sharp spiny type mentioned by Coker (**2**), and ranged in color from hyaline to light brown. Sparrow (**10**) has referred to the dark colored oögonial wall seen in fresh material of the Arlington collection, but this character was not apparent in the preserved material. However, it is reasonable to suppose that the color may have faded in the glycerin mounts. Beyond emphasizing the basal application of the antheridia and the fact that the oöspore almost completely fills the oögonium at maturity, nothing of importance can be added to Coker's original description.

Aphanomyces Sparrowii sp. nov.

This fungus was studied by Sparrow (**10**) in 1930 and reported as *A. phycophilus*. Later he revised his opinion (Sparrow, **12**) and pointed out that it was too small and delicate a form to be referable to that species. *A phycophilus* has oögonia which measure 40–50 μ in diameter, whereas those of the present fungus do not exceed 25 μ in diameter. The ornamentation of the oögonial walls of this species which bear very conspicuous sharp pointed spines is quite distinct from the prominent blunt tubercles typical of *A. phycophilus*. The spines in *A. Sparrowii* often exceed the diameter of the oögonium and are frequently bifurcated (FIG. 3). Further study has shown that it is not identical with any previously described form. It is easily separated from *A. exoparasiticus* Coker & Couch, the species with which it shows the closest affinity, by the smaller oögonia, oöspores with eccentric oil globules, and by the conspicuous golden coloration of oögonia and oöspores. Further differences are found in the disposition of the antheridial branches which do not twine around the oögonial stalks in the characteristic manner of *A. exoparasiticus,* and in the short, slender lateral sporangia which are quite different from those of the aforementioned species. From *A. parasiticus* and *A. amphigynus,* the other closely related forms, *A. Sparrowii* is distinguished by its much more prominent spines and the generally larger dimensions of the oögonia, by the golden color of the oögonial wall, and by

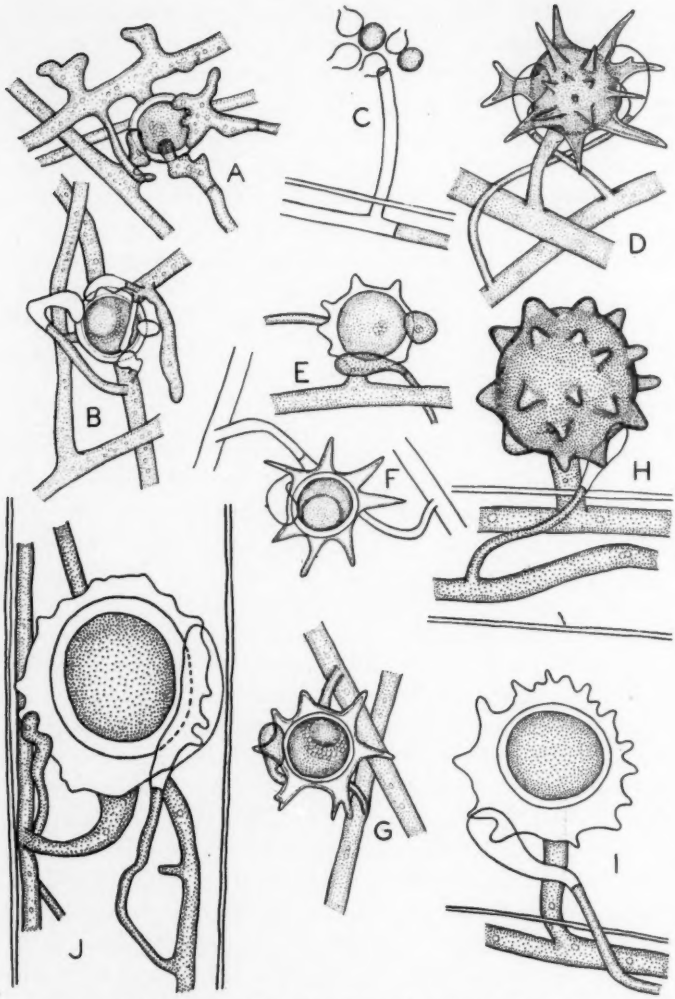


FIG. 15. All drawings made with the aid of a camera lucida, at an approximate magnification of 600 diameters. *A–B, A. laevis* forma, oögonia on the exuvia of a mayfly (note short and convoluted antheridia); *C, A. Sparrowii,* lateral zoösporangium with cystospores and empty cysts; *D–G, A. Sparrowii,* types of oögonia and antheridia growing on *Nitella* sp. (note very prominent spines and clavate antheridia; *H–J, A. phycophilus,* on *Spirogyra* sp.; oögonia and antheridia.

the thick walled oöspore. The lateral rather than basal application of the antheridia further distinguishes *A. Sparrowii* from these species. So far as is known this is the only species of *Aphanomyces* ever reported as parasitic on *Nitella*. Sparrow (**10**) has discussed the non-sexual stage of this fungus and nothing of importance can be added to his description except to emphasize, as he points out (**12**), that this is quite distinct from *A. phycophilus* de Bary. The species is named in honor of Dr. F. K. Sparrow, Jr., who collected it, and first recognized its unique character.

Hyphae hyaline, 6.5–14 μ in diam., scarcely branched, extending through the host tissue; sporangia short, lateral, thinner than the vegetative mycelium, 3.5–5 μ in diam., penetrating the host wall; zoöspore discharge not observed but presumably typical; cystospores 5–12 in number, 7–9 μ in diam.; oögonia borne on short lateral branches within the host cell, 16–25 μ in diam. exclusive of the spines; oögonial wall 1–1.5 μ thick, golden, unpitted, produced into numerous very prominent thick walled, frequently bifurcated, spines, 4.5–14 μ in length; oöspores single, golden, 14–22 μ in diam. with prominent eccentric oil globule, oöspore wall 1.5–3 μ thick; antheridia 1–3 to an oögonium, diclinous, bent clavate, borne on slender branches, persistent after fertilization.

Hyphae hyalinae, 6.5–14 μ crassae, parce ramosae, intramatricae; sporangia brevia, lateralia, tenior myceliis sterilibus, 3.5–5 μ crassa, perforentia murum hospitis; emissio zoosporarum non observata, sed manifeste propria; cystospora 5–12 num., 7–9 μ dia.; oogonia prolata brevibus lateralibus ramis, in cella hospitis, 16–25 μ dia. sine spinis; murus oogoniarum 1–1.5 μ crassus, flavens, sine foramenibus, eductis in multis prominentibus saepe bifurcatis spinis cum muris crassis, 4.5–14 μ long.; oosporae solitariae, flaventes, 14–22 μ dia. cum prominente eccentrico globulo, murus 1.5–3 μ crassus; antheridia 1–3, declinus, incurva clavata, super gracilis ramos, constantia post evacuaverunt.

Known from one collection in the internodal cell of a species of *Nitella* from Cold Spring Harbor, N. Y. Coll. F. K. Sparrow, Jr.

APHANOMYCES SCABER deBary, Jahrb. Wiss. Bot. p. 178. *Pl. 19.* 1860. FIGS. 6, 14 *E–I.*

This species appears to be predominantly saprophytic, but has been reported as parasitic on *Achlya* by Couch (**3**) and on *Spirogyra* by Humphrey (**7**). The present material, collected at Ithaca,

N. Y., by Sparrow and called *A. norvegicus* by him, occurred as a parasite on *Spirogyra*. Great numbers of oögonia were formed within the infected algal filaments with occasional ones borne on short stalks outside the host cells. The form and dimensions corresponded well with de Bary's original description. In contrast to the strain of *A. scaber* described from Chapel Hill, N. C., by Coker (**2**) and Couch (**3**) which lacked antheridia, the present material bore antheridia on at least ninety per cent of the oögonia. In some cases two antheridia were present on an oögonium. The ornamentations of the oögonial wall were extremely variable, ranging from mere irregularities to definite tuberculations. In its more extreme forms the oögonial walls approached the type of *A. phycophilus* de Bary, but it was immediately distinguished from that species by the much smaller dimensions of the oögonia (see table below), and the centric nature of the oil globule in the mature oöspore. The only other species with which it might be confused is *A. parasiticus*, from which it can be easily separated by the thick oöspore wall (1.5–3 μ) and the centric oil globule, as well as by the lateral application of the antheridia. In our material no zoösporangia were observed. Coker (**2**) states that the oöspores are eccentric, but in our material the oil globules were definitely centric in position. This difference cannot be given too much weight, however, since the material was not seen in the living state.

APHANOMYCES PHYCOPHILUS deBary, Jahrb. Wiss. Bot. pp. 179–182. *Pl. 20.* 1860. FIGS. 4, 5, 15 *H–J*.

Material of this species was studied from preserved material of *Spirogyra* sp. collected at Ithaca, N. Y., by Sparrow. The alga was heavily parasitized by two species of *Aphanomyces* which Sparrow (**12**) reported as *A. phycophilus* deBary and *A. norvegicus* Wille. Further study has indicated, however, that the species referred to *A. norvegicus* is quite typical of *A. scaber* deBary, and has been discussed under that species.

The material referred to *A. phycophilus* by Sparrow (**12**) appears in many respects to coincide with the original description of *A. norvegicus*. Wille (**16**) in his diagnosis of that species failed to give any measurements for his fungus, and separated it from *A. phycophilus* only on the basis of the brown coloration of the

oögonial walls, and on the fact that the fungus hyphae frequently encircle the algal filaments as well as transversing them. Both species were until recently known only as obligate parasites of the Conjugatae. Whiffen (**15**) has demonstrated, however, that *A. phycophilus* may be cultured as a saprophyte on agar. Couch (**3**) and Whiffen (**15**) have both shown that the oögonial wall may become brown at maturity, and that the hyphal threads often extend outside the host cells. Weatherwax (**14**) has described a form from Indiana with a hyaline oögonial wall that corresponds well with the original description of *A. phycophilus,* save in the somewhat smaller diameters of the oögonia, which average 26 μ in contrast to the 40–50 μ recorded by de Bary. In our material the oögonial walls range from hyaline to dark brown and the threads of the parasite occur both inside and outside the host filament. To judge from these accounts neither the color of the oögonial walls nor the orientation of the hyphal threads is a reliable criterion for the separation of *A. norvegicus* from *A. phycophilus,* since both characters are dependent in large measure on the age of the material and the degree to which infection of the host has occurred. Due to the inadequacy of Wille's original description of *A. norvegicus,* and to the obvious difficulties of separating it from *A. phycophilus,* which appears to be a rather variable species, we are led to the conclusion that there is little cause for retaining the former species in the literature. Gicklhorn (**6**) has described a species, *A. ovidestruens,* parasitic on the eggs of *Diaptomus,* which in its sexual stage might be confused with *A. phycophilus,* but the curious nature of the swollen basal holdfast cell on the vegetative mycelium, and the fact that it is only parasitic on living animals, indicates that it is distinct from the present species.

In the Ithaca material of *A. phycophilus,* the thickness of the oöspore wall was very noticeable, in extreme cases reaching 5.5 μ. A further peculiarity of this fungus was the apparent lack of any oil globule in the mature oöspore. De Bary (**4**) states that the contents of the oöspore are homogeneous, and neither Coker (**2**) nor Couch (**3**) mentions the presence of an oil globule. Whiffen (**15**) describes the contents of the mature oöspore as finely granular with oil droplets around the periphery. In this respect *A.*

Species	Oögonial Wall Ornamentation	Oögonial Diameter	Oögonial Coloration	Oöspore Diameter	Oöspore Coloration	Oöspore Wall Thickness	Nature of Oil Globule	No. of Antheridia per Oögonia	Antheridial Characters	Application of Antheridia
A. laevis	smooth	24–35 μ	hyaline	19–29 μ	hyaline	1.5–3 μ	eccentric	1–6 μ	diclinous androgynous	indiscriminate
A. laevis, forma	smooth	15–21 μ	hyaline	12–18 μ	hyaline	1.5–2 μ	eccentric	3–5 μ	diclinous on short branches	indiscriminate
A. helicoides	smooth	21–35 μ	brownish	16–27 μ	brown	0.5–1 μ	eccentric	1–5 μ	diclinous coiling around oögonial stalks	indiscriminate
A. Sparrowii	long, sometimes bifurcated spines 4.5–14 μ	16–25 μ	golden	14–22 μ	golden	1.5–3 μ	eccentric prominent	1–3 μ	diclinous bent-clavate	indiscriminate
A. parasiticus	sharp spines 2–4 μ	14–24 μ	hyaline to light brown	12–23 μ	hyaline	1 μ	eccentric prominent	1 μ	diclinous	basal
A. amphigynus	blunt spines or tubercles up to 2.5 μ	12–16 μ	hyaline	9–13 μ	hyaline	1 μ	eccentric or subcentric	1 μ	diclinous or androgynous very large 9 × 14 μ	basal
A. scaber	rough or with broad tubercles up to 3 μ	16–26 μ	hyaline to very light brown	12–20 μ	hyaline	2.5–4 μ	subcentric or centric small	0–2 μ	diclinous sometimes apandrous	indiscriminate
A. phycophilus	heavy sharp tubercles up to 9 μ	39–55 μ	hyaline to deep brown	35–43 μ	hyaline to brown	3–5.5 μ	no globule	1–3 μ	diclinous tuber-shaped	indiscriminate

[2] Since submitting this paper for publication a recent contribution by R. L. Smith (Studies on two strains of *Aphanomyces laevis* found occurring as wound parasites on crayfish), MYCOLOGIA **32**: 205–213, *fig. 1*, 1940, has come to my attention. This author's observations on the nature of the oöspore wall of *A. laevis* are not substantiated in the material discussed in the present paper.

phycophilus is unique among the species of the genus. The oögonia in our material were borne inside and outside the host in about equal numbers. Those born inside were frequently egg shaped due to compression by the walls of the host cells. The hyphal measurements of our fungus were somewhat smaller than those of de Bary's description, averaging 7–10 μ in diameter as compared to 10–15 μ in de Bary's form. No sporangia were encountered in this material which substantiates Couch's statement (**3**) regarding the rarity of this type of reproduction. Sparrow's description of the non-sexual reproduction of *A. phycophilus* (**11**) has been shown above to apply to a previously undescribed form.

DISCUSSION

In the study of water molds under natural conditions certain characteristics commonly used in the classification of these fungi, such as the color of various organs, generally prove upon investigation of a large number of specimens to be so inconsistent as to be of little value in making specific separations. This is particularly true of those characters which are in large part merely the physiologic manifestations of the basic nature of the substrate. A case in point is the use of the color of the oögonial wall of certain species of *Aphanomyces* (*A. phycophilus, A. norvegicus*) as a characteristic of specific rank. During the course of this study many instances have been found where in a single culture and indeed in a single host filament oögonia occurred which possessed walls ranging in color from hyaline to deepest brown, and this on oögonia of approximately the same stage of maturity. In view of the extensive color variation displayed by some of these species it appears that in this genus the use of color as a character for specific separation is a somewhat doubtful procedure.

The accompanying table indicates that a considerable amount of intergradation occurs among those species of the genus forming ornamented oögonia, with respect to the type of ornamentation displayed by the oögonial wall. The same holds true for the diameter of the oögonia. With the exception of *A. phycophilus,* the oögonial dimensions of the species studied overlap rather widely at their extremes. On the other hand the characteristics of the

...laevis found occurring ... author's observations on the nature of the oöspore wall of *A. laevis* are not substantiated in the material discussed in the present paper.

oöspore such as the thickness of its wall and the position of the oil globule, and particularly the diameter of the oöspore in relation to the diameter of the oögonium, appear to be quite consistent among individuals of the same species. This is equally true in the smooth walled as well as in the spiny walled species that have been examined. From a large number of measurements and observations made on the above material we are led to the conclusion that the nature of the oöspore wall, and the position and appearance of the oil globule, present usually reliable characteristics for the separation of species.

The disposition, shape and manner of application of the antheridia are obviously important taxonomic features. In certain species such as *A. parasiticus* and *A. amphigynus* the antheridial characteristics are remarkably consistent. However, in certain other species, particularly *A. scaber* and *A. laevis,* the accounts of various workers (Coker, **2**, Humphrey, **7**) indicate that the type and nature of the antheridia are extremely variable; and indeed apandrous strains of these species apparently occur. Furthermore, it is frequently most difficult to determine with certainty the precise origin of the antheridial branches, and the exact application of the antheridia to the oögonia in cases where fertilization tubes are not developed. Hence we feel that, with the exceptions noted above, the antheridial characters cannot be considered too reliable in delimiting species. The nature and shape of the zoöspores and cystospores in the material that we have examined in the living state appear to be fairly constant for any one given species, and perhaps offer another reliable criterion for specific designation.

It is evident that a large number of isolates of these species must be collected from many sources and grown and studied in pure culture under identical conditions before our conception of the specific limits within the genus *Aphanomyces* becomes firmly established. The results of this study indicate that some of these species are extremely variable and the limits of this variation are not yet clearly defined.

SUMMARY

1. Eight species and one form of the genus *Aphanomyces,* from a number of collections, have been studied critically to determine

those characteristics which serve to demarcate most clearly the various species.

2. At the present time the oöspore characters appear to offer the most reliable criteria for the separation of the species studied.

3. *Aphanomyces helicoides* Minden is reported for the first time from America.

4. A species of *Aphanomyces, A. Sparrowii,* parasitic on *Nitella,* is described.

5. A species of *Aphanomyces* most closely related to *A. parasiticus,* but differing in its saprophytic nature and smaller dimensions, is described as *A. amphigynus.*

6. A form of *A. laevis* which differs from the species in the much smaller dimensions of oögonia and oöspores and in the diverticulate nature of the antheridial cluster is discussed.

In closing, the writer takes great pleasure in expressing his deep appreciation to Dr. F. K. Sparrow, Jr., who has given generously of both time and materials and under whose direction this study was carried out. He is also indebted to Mrs. Lucy Olson, who prepared the Latin diagnoses contained in this paper, and to the Department of Botany of the University of Michigan, who extended the privileges of their laboratories.

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LITERATURE CITED

1. **Bartsch, A. F. & Wolf, F. T.** Two new Saprolegniaceous fungi. Am. Jour. Bot. **25**: 392–395. *figs. 1–11.* 1938.
2. **Coker, W. C.** The Saprolegniaceae, with notes on other water molds. 1–201. *illus.* Chapel Hill, N. C. 1923.
3. **Couch, J. N.** Notes on the genus *Aphanomyces,* with a description of a new semiparasitic species. Jour. Elisha Mitchell Soc. **41**: 213–226. *pl. 26–33.* 1926.
4. **de Bary, Anton.** Einige neue Saprolegnieen. Jahrb. Wiss. Bot. **2**: 170–180. *pl. 19–20.* 1860.
5. **Drechsler, C.** The beet water mold and several related root parasites. Jour. Agr. Res. **38**: 309–361. *figs. 1–17.* 1929.
6. **Gicklhorn, J.** *Aphanomyces ovidestruens* nov. spec.—Ein Parasit in den Eiern von *Diaptomus.* Lotos **71**: 143–156. 1923.
7. **Humphrey, J. E.** The Saprolegniaceae of the United States, with notes on other species. Trans. Am. Phil. Soc. (n. s.) **17**: 63–148. *pl. 14–20.* 1893.

8. **Minden, M. von.** Pilze I. Phycomycetes. Krypt.-fl. Brand. **5**: 555–562. *illus.* 1915.
9. **Petersen, H.** An account of Danish Freshwater-Phycomycetes. Ann. Myc. **8**: 494–559. *fig. 3.* 1910.
10. **Sparrow, F. K., Jr.** The non-sexual stage of *Aphanomyces phycophilus.* Mycologia **22**: 118–121. *fig. 1.* 1930.
11. ——. Observations on the aquatic fungi of Cold Spring Harbor. Mycologia **24**: 268–302. *pl. 7–8.* 1932.
12. ——. Inoperculate chytridiaceous organisms collected in the vicinity of Ithaca, N. Y., with notes on other aquatic fungi. Mycologia **25**: 513–535. *pl. 49.* 1933.
13. ——. A contribution to our knowledge of the aquatic Phycomycetes of Great Britain. Jour. Linn. Soc. **50**: 417–478. *figs. 1–7. pl. 14–20.* 1936.
14. **Weatherwax, P.** *Aphanomyces phycophilus* de Bary. Proc. Ind. Acad. **1913**: 109–111. *figs. 1–6.* 1914.
15. **Whiffen, A. J.** *Aphanomyces phycophilus* in culture. Am. Jour. Bot. **25**: 649–650. *figs. 1–7.* 1938.
16. **Wille, N.** Om Nogle Vandsoppe. Vidensk. Selsk. Skr. Christiana (Mat.-Nat. Kl. ser. 1) (3): 1–13. *figs. 1–27.* 1899.